Narda
Model 61A1

Narda
61A1

ERRATA SHEET NO. 1

MODEL 61A1 MICROWAVE RECEIVER

Publication SJ-26-0084A

Page 41. Change the value of R411 from 4700 Ω (same as R403) to 5600 Ω. Sperry Part number 0524-67 (1/2w composition ±5%.)

Page 42. Change R509 from same as R107 to RESISTOR: Fixed, Composition, 1/2 w 5100 Ω 0524-66.

Page 55-56. Change the value of R411 on schematic from 4700 Ω to 5600 Ω.

Page 57-58. Change value of R509 from 10K to 5100 Ω.

narda *Microline*

Model 61A1
MICROWAVE RECEIVER

SERIAL NO. 261 UP

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SPECIFICATIONS

FREQUENCY RANGE 10 Mc to 40 Gc

INPUT FREQUENCY 30 Mc

ACCURACY

	Attenuation (db)	Max. Error (db)	Attenuation (db)	Max. Error (db)
	10	±0.06	60	±0.25
Single	20	±0.08	70	±0.30 *
Step	30	±0.10	80	±0.35 *
	40	±0.15	90	±0.40 *
	50	±0.20	100	±0.50 *

	Input Level to Mixer	Maximum Error
10 db Increments	-10 to -25 dbm	±0.12 db/10 db
	-25 to -80 dbm	±0.06 db/10 db
	-80 to -95 dbm	±0.12 db/10 db *
	-95 to -110 dbm	±0.20 db/10 db *

NULL RESOLUTION

0.008 db per division to -95 dbm with NULL switch in X1 position
0.08 db per division to -95 dbm with NULL switch in X10 position
0.05 db per division to -110 dbm with NULL switch in X1 position
0.5 db per division to -110 dbm with NULL switch in X10 position

* Microwave signal source externally modulated by 61A1

SPECIFICATIONS (Continued)

I-F AMPLIFIER	Center frequency: 30 Mc Bandwidth: 1 Mc Noise figure: 1.5 db max. Output: 0-30 volts linear to 3%; 60 db log (0-30 volt range) to 3%; AGC, approximately 2 volt output Overall effective noise figure: (including input switch) 3 db or better Gain variation: in excess of 65 db
REFERENCE OSCILLATOR	Crystal-controlled oscillator, 30 Mc ±0.02% Amp. stability, 0.005 db/10 minutes
COMPARISON SETUP	Switching rate: 1 kc Signal switching: internal or external - 1 kc square wave output, 10 V p.p.
30 MC ATTENUATOR	0 to 100 db indication with in-line readout (least division 0.02 db) "0" insertion loss approximately 23 db Accuracy: 0.05 db/10 db; 0.10 db max.
OUTPUTS	A-c video on front panel D-c video on rear of chassis Recorder jack on output VTVM, 0 to 1 ma, 1500 ohms, one side ground 30 Mc output from reference oscillator on rear of chassis
OUTPUT LEVEL INDICATOR	D-c video ranges; 1, 3, 10, & 30 volts full scale Log d-c video; 0-60 db range, 20 volts full scale A-c video; 10 volts full scale Mixer crystal current; 3 ma full scale, positive or negative polarity
FREQUENCY DEVIATION INDICATOR	Center zero; approx ±150 kc full scale
NULL INDICATOR	Center zero; resolution per above
AFC UNIT	Correction voltage range: ±25 volts centered on input reflector voltage Control current: 0 to 20 ma either polarity Sense: selected + or - from panel Insulation: 5000 volts for beam plus reflector AFC Center Frequency: Locked to reference oscillator frequency for comparison mode; Locked to discriminator center frequency for standard receiver mode AFC Loop Gain: Adjustable by control on rear panel
POWER	105-125/210-250 volt, 50-60 cps line Approximately 150 watts
WEIGHT	55 pounds, including case
SIZE	12½ wide x 18 high x 19 deep; 10½ rack mount panel

INTRODUCTION

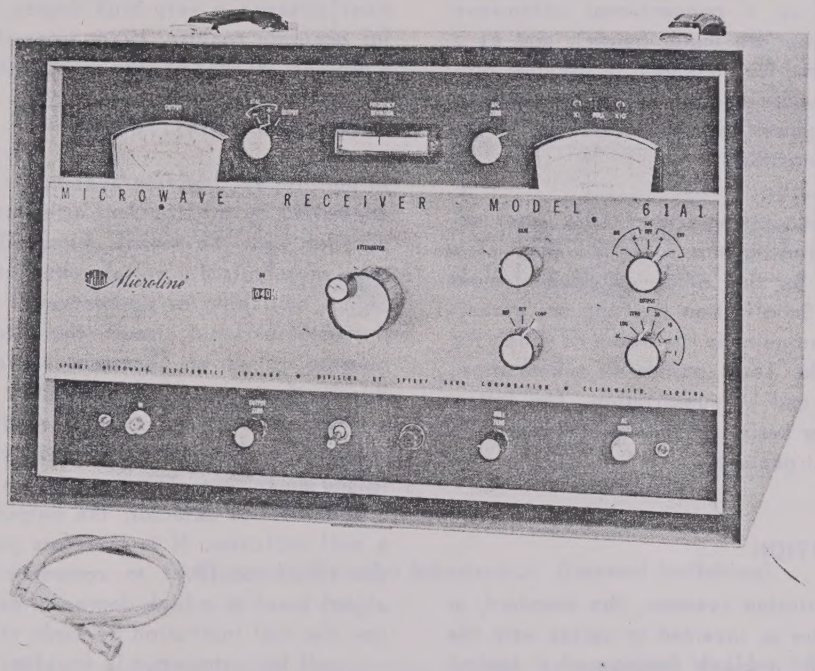


Figure 1. Sperry *Microline* **61A1 Microwave Receiver**

The Sperry *Microline* 61A1 Microwave Receiver is a unique and versatile instrument, capable of performing highly accurate measurements over the frequency range from 10 mc to 40 gc. This unit can be used with standard waveguide and coaxial instruments to make attenuation measurements of 100 db or more in a single step, and to calibrate signal generators or make absolute power measurements at levels as low as -110 dbm. Measurements are accomplished using the parallel i-f substitution technique.

In addition, the Sperry *Microline* 61A1 Microwave Receiver may be used as a conventional lin-log receiver over an extremely wide range of frequencies, 10 mc to 40 gc, by the use of standard, readily available waveguide and coaxial components and single-ended crystal mixers such as the Sperry *Microline* 34( )1 Tunable Detector-Mixer Mounts. For antenna pattern measurements, a 60-db log scale and recorder output are provided. In conventional linear operation the unit can be used as an extremely sensitive microwave detector.

THEORY OF OPERATION

The primary function of the Sperry *Microline* 61A1 Microwave Receiver is the measurement of relative power levels. It may also be used for absolute power indication, as a conventional microwave receiver (with appropriate mixer heads), and as a log response receiver for passband or antenna pattern plotting. This discussion will be concerned primarily with the power ratio measurement, or the measurement of attenuation.

Attenuation measurements are made most accurately by substituting the insertion loss of a calibrated element for that of an unknown element in the test setup. Substitution systems are classified according to the point in the setup at which the substitution is made. They include r-f substitution, audio substitution and i-f substitution. The latter, which may be either series or parallel, is generally considered the most accurate.

SERIES SUBSTITUTION

In series i-f substitution systems, the standard, or reference, attenuator is inserted in series with the signal. Figure 2 is a block diagram of a typical series substitution arrangement. A preamplifier is required in the signal path prior to the attenuator to prevent serious degradation of receiver noise figure due to attenuator insertion loss. With this arrangement, it is extremely difficult to realize the full accuracy capabilities of the attenuator over a wide dynamic range because of non-linearity in the preamplifier. In addition the level indicator, in series substitution equipment, must operate on d-c, making it difficult to display small excursions with good stability. Perhaps the most serious disadvantage of this method is the sensitivity to gain changes in the system. Both the preamplifier and the i-f strip must possess a very high degree of gain stability for accurate results. Mixer linearity is not usually a problem, except at high signal levels.

PARALLEL SUBSTITUTION

In parallel substitution systems, a reference signal controlled by the standard attenuator is inserted in parallel with the signal. Figure 3 is a block diagram of a typical parallel substitution arrangement. Signal switching or modulation is accomplished in the receiver input circuit; the setup shown will be referred to as an "internal switching" setup. In this method, the i-f strip input is alternately connected to the signal and to the reference oscillator output from the attenuator by a switching operation in the equipment. The two signals are compared in a synchronous detector; the output is displayed by a null indicator. It is therefore possible to adjust the reference level to correspond to changes in signal level to a high degree of accuracy. Not only can the null indication be made very sensitive, but any null indicator error is constant and cancels out. All major disadvantages of the series substitution system are eliminated since there is no preamplifier, gain changes in the i-f strip affect the signal and the reference equally, and a synchronous detector is used which permits stable indication of small changes in signal level. It is possible to realize the full accuracy of the attenuator over wide dynamic ranges, except for the extreme ends of the operating range, since errors other than the attenuator are virtually eliminated.

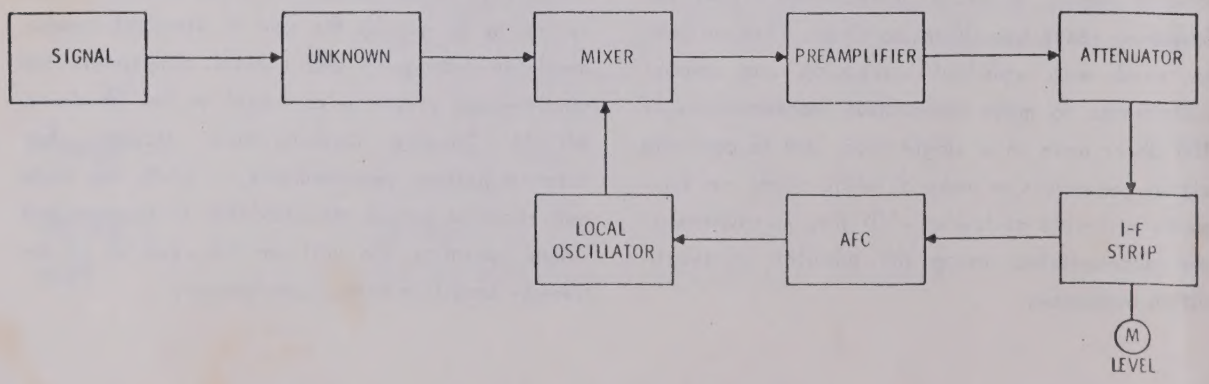


Figure 2. Series Substitution

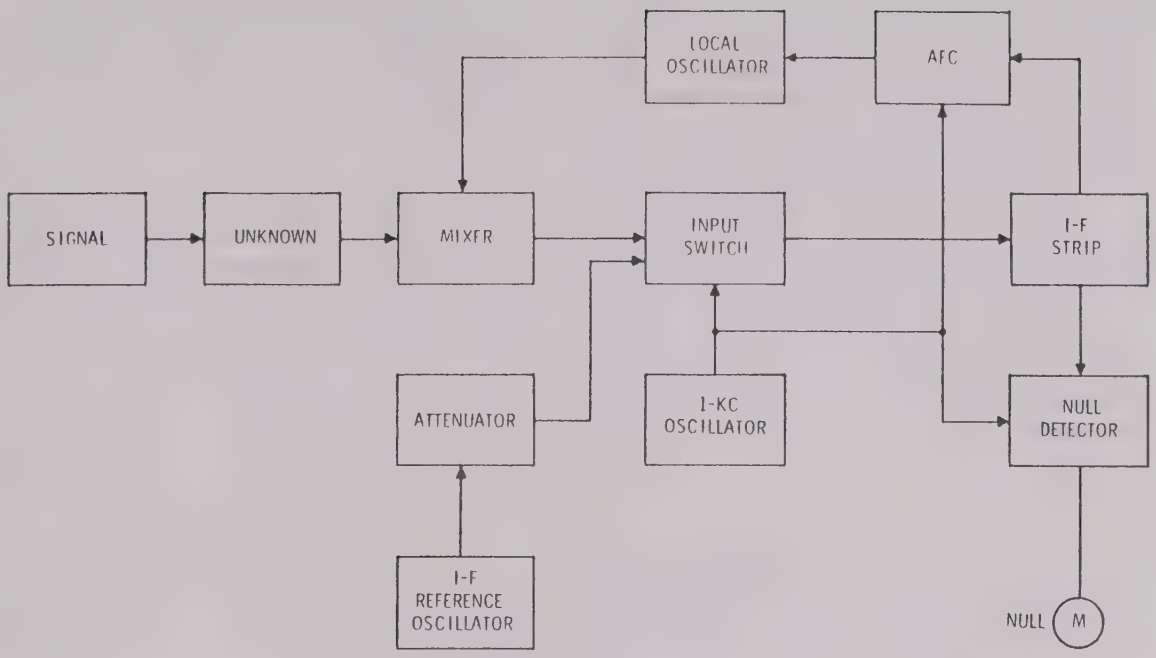


Figure 3. Parallel Substitution (Internal Switching)

At the high level end of the signal range, mixer non-linearity will be significant when the signal is no longer small compared to the local oscillator level. There is approximately 0.05 db error when the local oscillator signal is 20 times greater than the signal; the error increases considerably as the ratio decreases.

The lower end of the measurement range is determined by system noise figure. Noise output from the mixer is switched as well as the 30-mc signal from the mixer. When mixer noise is no longer small compared to the signal, it will result in a measurement error since the internal reference is being compared to the net input signal. In the 61A1, a dynamic range of approximately 75 db (-10 dbm upper limit) can be covered satisfactorily using internal switching. The lower limit of approximately -85 dbm can be realized with a single-ended mixer and approximately 10 db mixer noise figure. Mixer noise coherence may be eliminated by switching the signal externally as described below, resulting in an extension of the lower limit.

Since the signal and the reference are alternately applied to the i-f strip, the two frequencies may be compared and an AFC correction voltage generated. A synchronous detector is used in the AFC unit and the incoming signal is locked to the reference oscillator frequency.

Null or balance indication is very nearly constant over the entire measurement range. Sensitivity is decreased at the lower end of the range because of system noise.

Waveguide mechanical instabilities, power supply changes, and other variations in the set up may cause null meter deflections which make it difficult to determine a null accurately. Under such conditions, the null sensitivity can be reduced to maintain a useable indication. On the 61A1, a front panel switch is included to permit a 10:1 reduction in sensitivity if desired.

EXTENSION OF DYNAMIC RANGE

Dynamic range may be extended at the lower end by removing mixer noise coherence. Elimination of mixer noise coherence requires signal modulation prior to mixing rather than after it. Signal switching or modulation is therefore performed at the external

source; the setup shown in figure 4 will be referred to as an "external switching" setup. In the r-f setup, the signal source is modulated 180 degrees out of phase with the 61A1 internal reference by using the 1 KC OUTPUT signal. The modulated signal and the modulated reference are then applied to the i-f strip input in the presence of a constant mixer noise level. With mixer noise modulation removed, measurements are possible at input signal-to-noise ratios considerably less than 1. The lower measurement limit is still determined by the mixer noise in a given setup; however, with commonly encountered noise figures, accurate measurements are easily made down to -110 dbm. AFC operation is identical to that used in internal switching.

SOURCES OF ERROR

The parallel substitution system inherently has less error than the series substitution system because nearly all the equipment is common to both the signal and reference. If there were no external error sources, measurement errors would be reduced essentially to those of the attenuator. Accuracies of 0.05 db/10 db or better are not uncommon for cut-off type attenuators in i-f substitution systems; therefore, excellent accuracy is obtainable in practice.

The mixer is the principal source of external error; however, it contributes significant error only at the extremes of the operating range. At high levels, errors due to mixer non-linearity are present if the local oscillator-to-signal ratio is too small. For a given local oscillator power level, linearity error will appear, and increase rapidly as the signal increases above about 1/20 of the local oscillator level. The absolute input level at which errors become significant can be raised almost indefinitely by increasing the local oscillator level, with the upper limit being crystal burnout.

At low signal levels, mixer noise will introduce errors at very low signal-to-noise ratios. These errors can be reduced for a given receiver only by

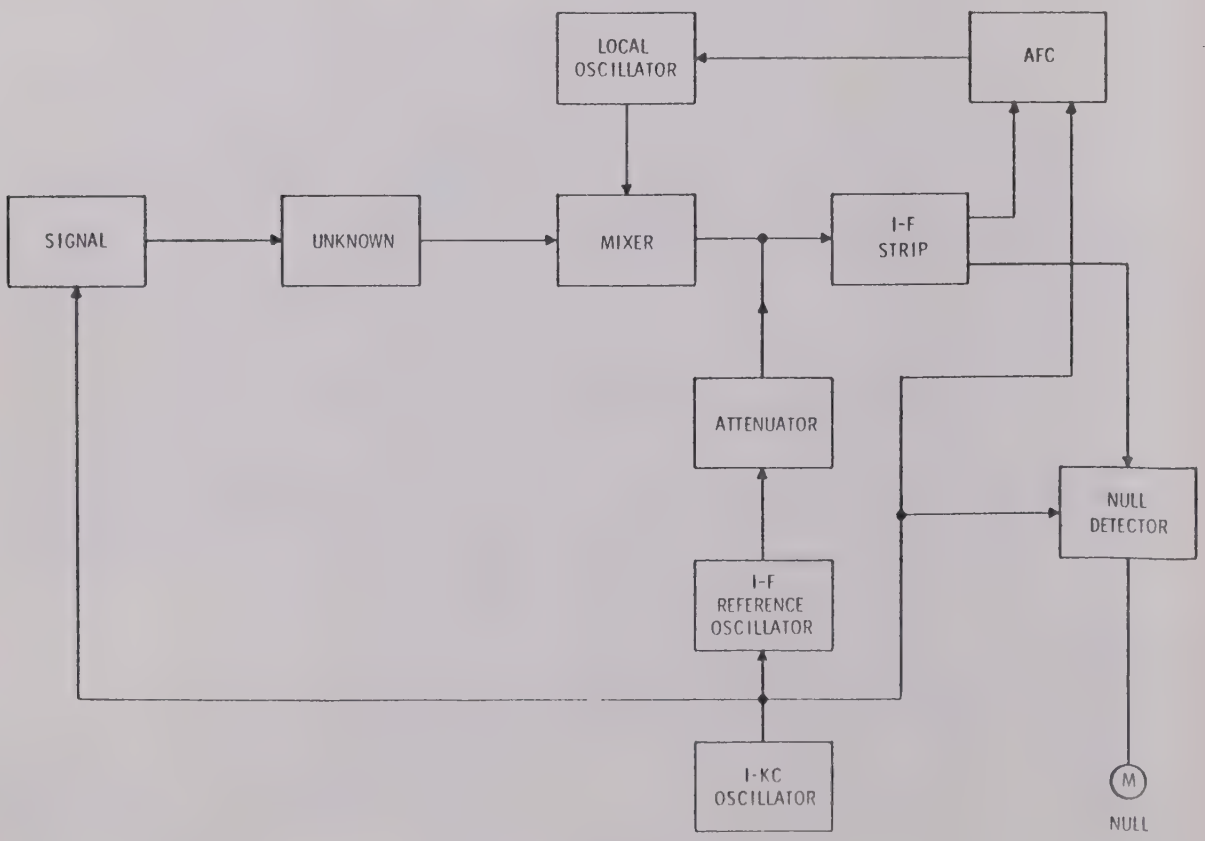


Figure 4. Parallel Substitution (External Switching)

improving the mixer noise figure. Some improvement can be made by reducing the local oscillator power; however, the local oscillator power can be reduced only until the conversion loss begins to increase. Once the conversion loss does begin to increase, it increases very rapidly, and overall performance deteriorates.

With respect to the mixer, the measurement range is limited at the lower end by noise (which increases with increased local oscillator power) and at the upper end by non-linearity (which can be improved only with increased local oscillator power). Total dynamic range increases somewhat as the local oscillator power increases since the lower end limit does not rise at the same rate as the upper end is improved. Minimum useful power level at the lower end will be higher, however, and the operating local oscillator level for measurements will usually be a compromise between the actual power levels involved and the dynamic range to be covered.

There are other factors which may contribute errors to the measurement, but they are difficult to evaluate for the general case.

CIRCUIT DESCRIPTION

A functional block diagram of the Microline 61A1 Microwave Receiver is shown in figure 5. Reference to the schematic diagrams will also be helpful at times in following the functional description.

INPUT SWITCH

The input switch has two functions, it modulates the 30-mc signal from the mixer when internal switching is used and it inserts the 30-mc reference oscillator signal from the attenuator on both internal and external switching modes. High conductance germanium diode switching elements are controlled by the application of the proper voltage polarity to the switching control line. When the switching voltage is negative, the input signal diode is biased off, disconnecting the mixer and connecting the cable; a compensating network is also inserted to replace the mixer resistance and capacitance which have been disconnected. Application of a positive voltage to the control line biases the compensation circuit diode off and turns on the signal diode. When internal switching is used, the positive and negative voltages are alternate half-cycles of the 1-kc square wave. In the external switching mode, the external signal source is modulated and a fixed positive voltage is applied to the switching line, disabling the internal signal switching operation. The mixer crystal current d-c return is connected to S604 to provide a crystal current indication on the OUTPUT meter.

ATTENUATOR

The attenuator is a waveguide-below-cutoff design. Its attenuation characteristics are related precisely to its physical dimensions; therefore, once the mechanical design is established, it is possible to reproduce an attenuator of known characteristics with excellent accuracy. The 61A1 attenuator uses a precision lead screw drive with an in-line counter readout. Attenuation error is 0.05 db/10 db or less. Two principal sources of error are variations in transmission tube diameter and errors in the lead screw. Tube diameter is closely controlled in the 61A1 attenuator and contributes little to any observed error. Lead screw errors tend to be cyclic rather than cumulative and permit overall measurement accuracy with the 61A1 of 0.5 db or better over a 100 db range. The attenuator input and output coupling circuits have a 50-ohm impedance and are broadly tuned at 30 mc.

REFERENCE OSCILLATOR

A two-stage vacuum tube oscillator supplies the 30-mc reference signal. A 3rd overtone crystal-controlled triode oscillator stage drives a pentode output amplifier to provide the necessary output level. Cathode bias in the pentode amplifier is adjusted to set the reference oscillator signal output voltage. An approximate 2.35-volt reference signal is available at the 30 MC OUTPUT jack (J603). Reference signal switching is accomplished in the reference oscillator by a high-conductance germanium diode in a manner similar to that of the input switch. Switching of the reference signal is accomplished prior to the attenuator to permit switching at a constant level, thereby removing any possibility of error due to switch variations with different levels. It also simplifies insertion of the reference signal when external signal switching is used. Filament and plate voltages for the reference oscillator are regulated for stable operation.

I-F STRIP

The i-f strip contains six tubes, four in the 30-mc amplifier and two in the AFC discriminator. High-performance frame grid tubes are used to obtain very stable i-f characteristics. These tubes are very uniform in characteristics from one tube to the next, minimizing the readjustment required when replacing i-f strip tubes.

A cascode input amplifier is used to obtain low noise figure. Two remote-cutoff pentode amplifiers permit smooth gain control with external voltages. A sharp-cutoff pentode amplifier drives the video detector which is a voltage doubler using two germanium diodes. The output signal from this ampli-

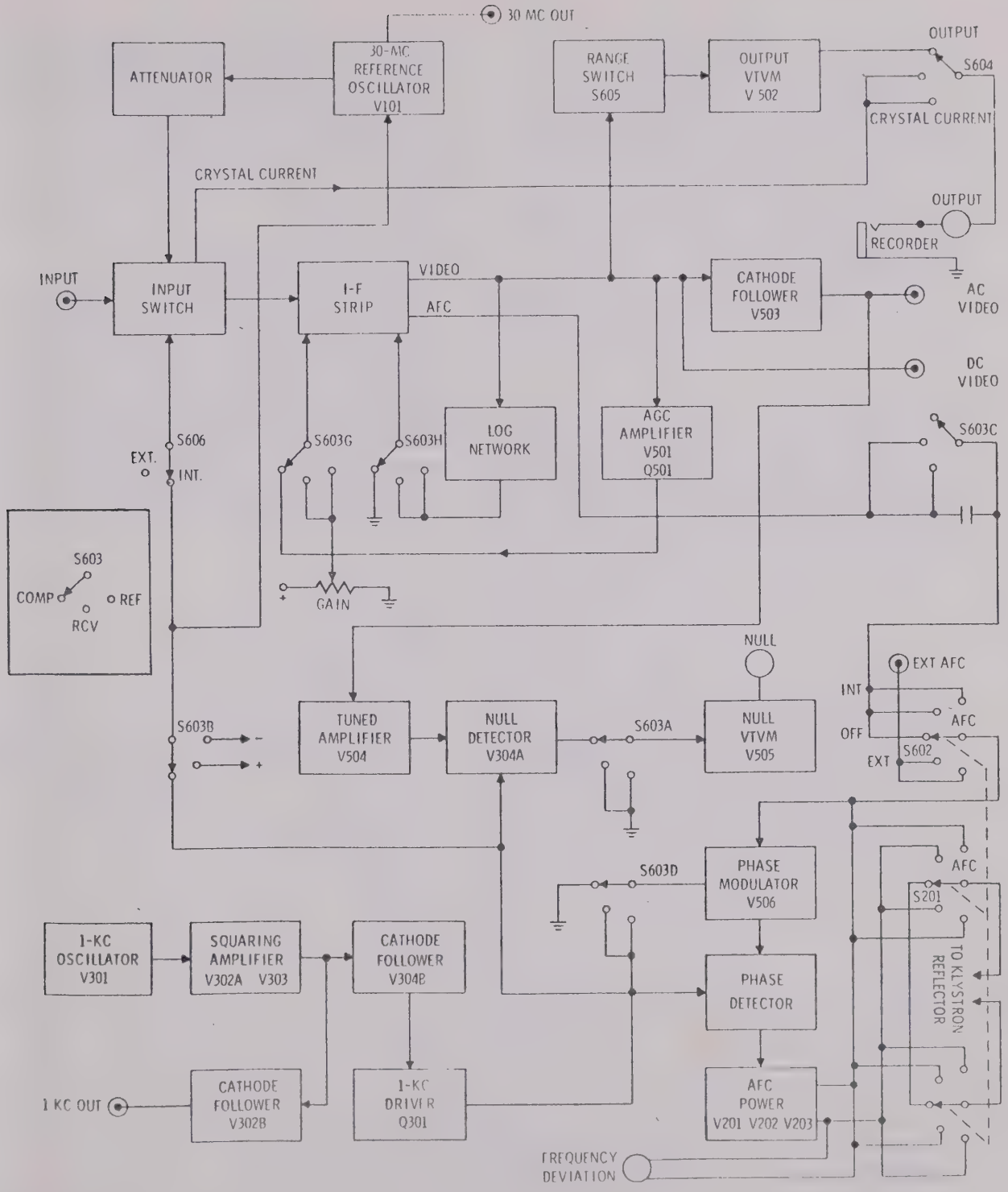


Figure 5. Microline 61A1 Microwave Receiver Functional Block Diagram

fier is also connected to a pentode limiter driving the dual-diode discriminator.

The amplifier is synchronously tuned throughout and has a bandwidth of approximately 1 mc at the 3 db points. I-f strip noise figure is 1.5 db or better; however, losses in the input switch result in an overall 61A1 noise figure of approximately 3 db. AFC discriminator sensitivity is approximately 4 volts/mc.

Both cathode and grid returns for the remote cutoff stages are brought out for gain control purposes.

AGC AMPLIFIER (See simplified circuit, figure 6)

Automatic gain control of the i-f amplifier is required to maintain constant null sensitivity over the 61A1 operating range. For a given full scale sensitivity in db, there will be a corresponding voltage ratio at the i-f detector. However, a vtvm is used for null indication and operation is based on an absolute input voltage. It is therefore necessary to normalize the i-f strip output to permit a uniform db indication on the vtvm. In comparison operation, the 61A1 OUTPUT meter indicates AGC voltage applied to the i-f strip gain control line. The i-f detector output is very nearly constant over the operating range with AGC operation.

The AGC amplifier consists of a 2-stage vacuum tube d-c amplifier and a transistor. The d-c amplifier is conventional and uses an NE2A neon bulb for d-c coupling between stages. The transistor is inserted in the cathode return line of the i-f amplifier remote-cutoff stages; transistor current is controlled by the vacuum tube d-c amplifier. When the transistor is conducting fully, the voltage drop across it is only a few tenths of a volt and has little biasing effect on the i-f amplifier. However,

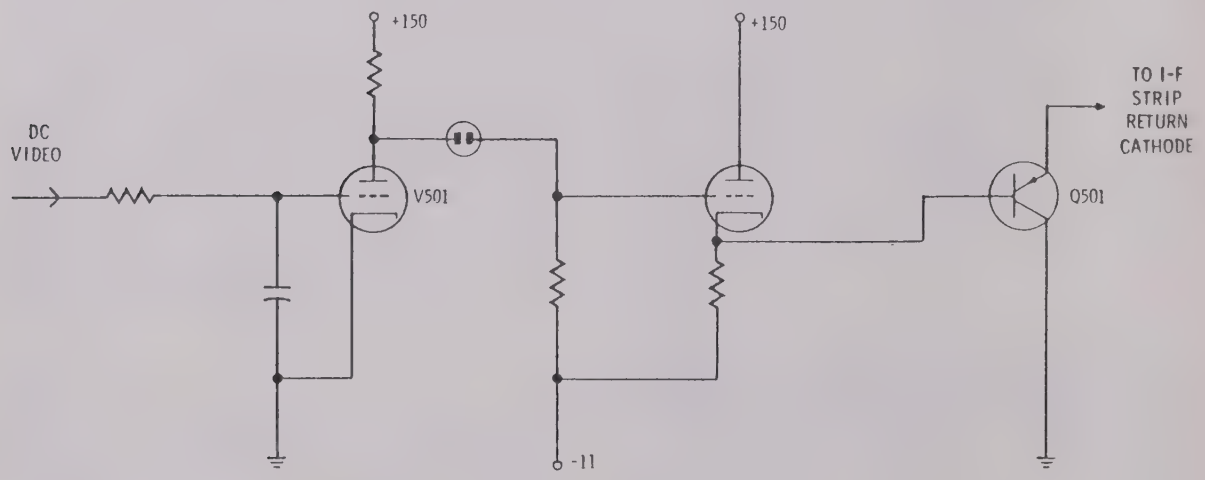


Figure 6. AGC Amplifier, Simplified Schematic

as the transistor drive is reduced, its current capacity is reduced, and the i-f stages are back biased, thereby reducing the gain. The AGC amplifier is used only on comparison operation. The cathode return line is grounded for log operation and connected to a manual gain control for other types of operation.

LOG NETWORK

In any amplifier using remote cutoff tubes, if the detected output is returned to the amplifier grids as bias, a response is obtained which approximates a logarithmic function. In the 61A1, a network is inserted in this feedback loop to shape the bias for true logarithmic response. Correction is adjusted for a logarithmic indication 60 db down from full scale on the OUTPUT meter. This method lends itself to convenient indication of passband response, antenna patterns, and similar applications; response is corrected to within 3% over the 60 db range.

OUTPUT VTVM

The output vtvm is a conventional balanced cathode follower circuit and is used to indicate video output, a-c video output and output voltage in log response. A separate isolated power supply is used for this circuit to permit grounding one side of the output meter circuit, facilitating use of a recorder or other output monitoring device.

CATHODE FOLLOWER (V503)

A conventional cathode follower is used to isolate the i-f amplifier output from the output jack and other circuits, using the a-c signal from the i-f video detector.

TUNED AMPLIFIER

The tuned amplifier includes the 1-kc parallel-tuned circuit and a two-stage amplifier. All circuits are conventional.

NULL DETECTOR (See figure 7)

The null detector consists of a half-wave semiconductor detector and a split-load phase inverter which applies a push-pull null signal to the detector. Reference signal drive for the detector is obtained from the 1-kc square wave driver. Operation of the null detector is conventional. The filtered output signal from the detector balance pot is applied to the null vtvm.

NULL VTVM

A straightforward balanced plate vtvm circuit is used with a zero center meter. Precision resistors are used in the amplifier plate circuit for stable operation over extended periods.

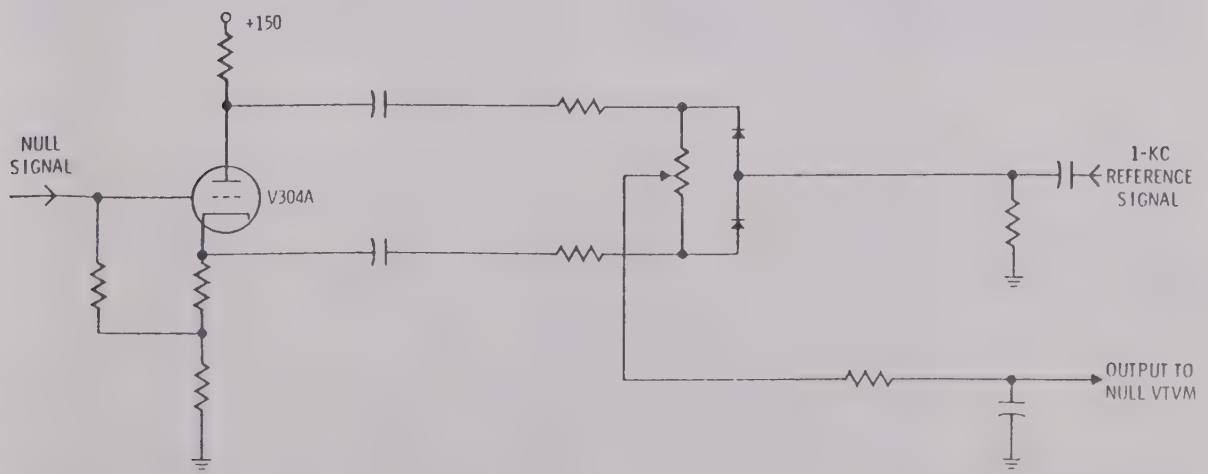


Figure 7. Null Detector, Simplified Schematic

1-KC OSCILLATOR

A bridged-T r-c tuned oscillator is used for the primary 1-kc source. Precision resistors and stable capacitors are used in the frequency determining circuit to provide long term frequency stability. The circuit is also stabilized, by a thermal element, against amplitude changes. The resulting circuit is not sensitive to tube characteristics.

SQUARING AMPLIFIER

The 1-kc oscillator output signal is amplified in a single triode amplifier and clipped in a two-stage regenerative slicer. Slicer bias and amplitude are selected for minimum phase offset between the output square wave and input sine wave.

CATHODE FOLLOWER (V304B) and 1-KC DRIVER

(Refer to the simplified circuit, figure 8)

The 1-kc square wave output of the slicer is applied to the 1-kc driver, an NPN transistor, through an isolating cathode follower. The cathode follower provides power gain for the transistor base circuit and drives it from full on to cutoff. When the transistor is turned on, collector current flows from the -11 volt supply through the transistor and a winding of T202 to ground. When the transistor is turned off, the field in the transformer winding collapses and generates the other half-cycle of the square wave of opposite polarity. To limit the voltage excursion associated with the collapse, a Zener diode and rectifier are used. When the transistor is on, the rectifier is biased in the reverse direction and does not conduct. When the transistor is off and the inductively generated voltage is present, the rectifier conducts and the Zener regulator operates.

CATHODE FOLLOWER (V302B)

A cathode follower isolation stage is used to couple the 1-kc square wave to the 1 KC OUTPUT jack. This also provides a low impedance output which is necessary to prevent deterioration of the square wave by cables which will be attached to the 1-kc output jack during operation.

PHASE MODULATOR (See figure 9)

The 61A1 AFC deck is used on both comparison and single signal operation.

In comparison operation, the input signal and the reference signal are alternately applied to the discriminator. If there is a frequency difference between them, the discriminator output is a square wave whose amplitude indicates the amount of difference and whose phase (with respect to the modulation) indicates whether the signal is above or below the reference. AFC operation attempts to minimize the 1-kc output of the discriminator and therefore locks the incoming signal to the reference frequency. This system is virtually independent of discriminator tuning.

In straight receiver operation, there is no switching. The discriminator output is a d-c voltage whose magnitude indicates the frequency difference between the signal and the center frequency tuning of the discriminator and whose polarity indicates the direction from the center frequency (above or below).

The phase modulator operates essentially as an amplifier with the comparison signal. In figure 9A, V506 is connected for comparison operation. V506

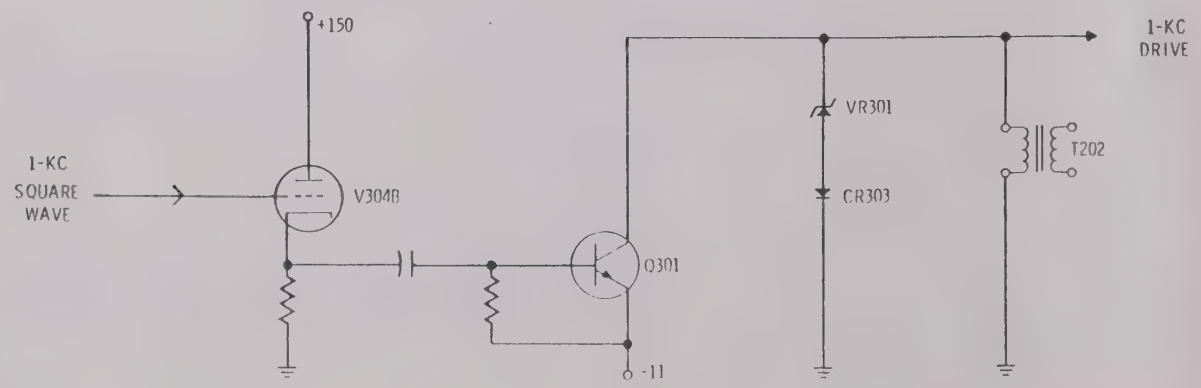


Figure 8. Cathode Follower and 1-Kc Driver, Simplified Schematic

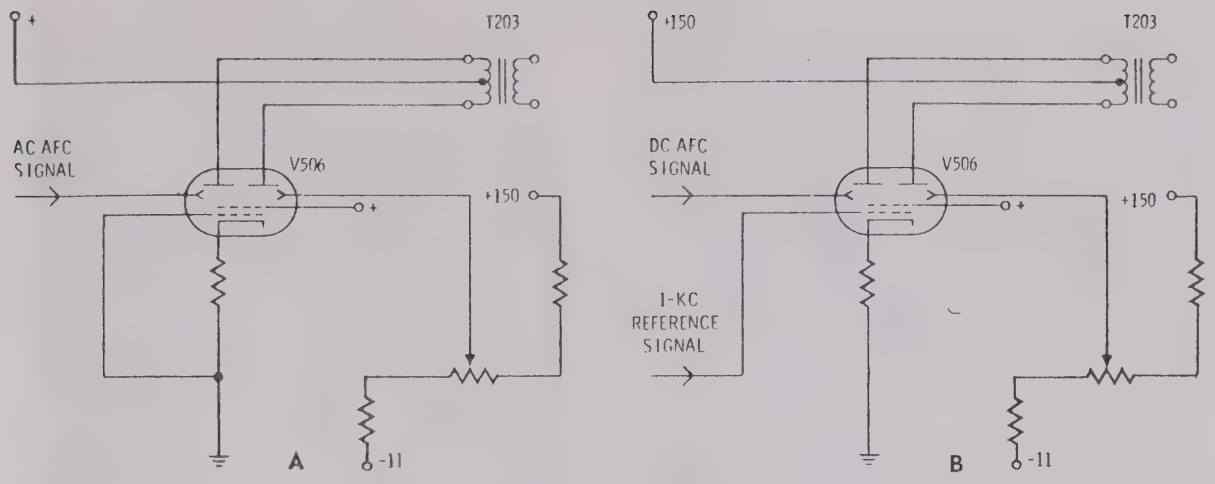


Figure 9. Phase Modulator, Simplified Schematic

is a sheet beam tube (6AR8) containing two plates and a pair of deflection electrodes. When the deflection electrode potentials to ground are balanced, the cathode current divides evenly between the two plates. As the potentials are unbalanced, the plate current balance will also shift, and a difference of potential will exist between the plates. Since a transformer is used in this circuit, only changes in plate current will be evident and the initial plate current balance is not important to proper operation. The signal grid of V506 is grounded for this mode of operation, and the tube function is essentially that of a phase inverter. The 1-kc output from the discriminator is applied to the deflection plate and appears as a push-pull signal on the primary of T202.

In straight receiver operation, it is necessary to generate the same push-pull signal from a d-c discriminator output. A 1-kc square wave is now applied to the signal grid as in figure 9B. If the two plate currents are balanced, they will generate square wave signals of equal amplitude on both plates. However, the net a-c voltage between the plates is zero since they both receive the modulated beam from the same source. If the amount of current is unbalanced, the plate signals are no longer equal and a net signal will appear on the transformer primary. The phase of the difference signal with respect to the grid signal will depend upon which way the beam was deflected. Therefore, if the tube is initially balanced, a positive signal on a deflection plate will generate one phase at the output and a negative signal will generate the opposite phase. In the 61A1, V506 is balanced with no discriminator output by the AFC ZERO control, which adjusts the deflection plate voltage on one half of the tube. D-c output from the discriminator is then applied to the other deflection plate and the a-c error signal is generated as in the case of comparison operation.

Under some conditions of operation the AFC loop gain may exceed its stable value, resulting in oscillation. This condition, which causes periodic oscillation of the FREQUENCY DEVIATION meter indication, is caused mainly by klystrons which have very high tuning rates with reflector voltage variation. The AFC GAIN control permits a reduction in the loop gain if this condition occurs.

PHASE DETECTOR

The phase detector uses two silicon rectifiers and operates as a full wave synchronous detector. Transformer T202 supplies the 1-kc reference signal and T203 couples the AFC signal from V506. Both transformers are insulated for 5000 volts working voltage to permit use with klystrons or other devices having voltage requirements up to that value.

AFC POWER SUPPLIES

A power supply with two regulators supplies voltage for AFC correction. One regulator operates

from a VR tube; the second regulator operates from the first. Since the two regulator output voltages are connected in opposition, it is only necessary that they be regulated with respect to each other. Outputs are set for a zero net voltage with no output from the phase detector. Voltage from the phase detector, corresponding to a signal from the AFC discriminator in the i-f strip, unbalances one of the supplies, providing a net difference between the two regulator outputs. The difference voltage will be positive or negative depending on the polarity of the phase at the detector output. This arrangement permits AFC correction on devices which draw current in the corrected circuit. The high impedance of reflector circuits used with klystrons require the use of the filter, R215, C207. Resistor R215 limits the AFC circuit current to a low value. Up to 20 ma current in the AFC circuit may be obtained by shorting resistor R215.

MAIN POWER SUPPLY

The main power supply furnishes

(a) floating 150-volt supply for the output vtvm,
(b) 6.3 volts a-c unregulated for filaments,
(c) -11 volts Zener-regulated d-c,
(d) -22 volts unregulated d-c,
(e) +150 volts regulated, and
(f) 6.3 volts rms regulated for filaments.

Circuits are conventional except for the +150-volt supply and the regulated filament supply.

In the 61A1, the B+ regulation is more important than a specific voltage (refer to the simplified schematic, figure 10). Drive for the gate transistor is obtained from a negative supply (which tends to turn it on) and from the positive supply through a VR tube (which tends to turn it off). The VR tube is a constant-voltage variable-current device which is well suited to controlling base drive on a transistor. The very low voltage drop of the transistor at relatively low current permits low supply voltage and low gate power dissipation. Regulator operation is straightforward. As the B+ tends to increase, base current decreases in the transistor, increasing its voltage drop and reducing the output voltage. If the supply should be short-circuited, the VR tube will extinguish and the transistor will attempt to pass saturation current which is limited by the size of R1 and the negative supply voltage. The 61A1 +150-volt supply is therefore not damaged by a short circuit. A prolonged short circuit on the +150 supply will cause the line fuse to fail, but will not damage the components in the power supply. When power is first applied to the 61A1, the +150 load (which is primarily vacuum tubes) is very light. Under these conditions, it is possible to exceed the maximum voltage rating on the gate transistor. The thermistor and NE2A neon bulb protect the transistor from overvoltage under temporary or transient conditions. With no current, the thermistor resistance is 3 to 4 times its operating resistance. When the transistor voltage drop reaches the ignition potential of the NE2A, it will light, limiting the voltage to approximately 65 volts and dropping the remainder across the thermistor. After the tubes warm up and the load is applied to the supply, the supply voltage drops, extinguishing the NE2A. The increased current heats the thermistor and reduces its resistance to the operating value. The NE2A does not operate except under high voltage conditions, such as initial turn-on. Output voltage from this regulator will vary with individual VR tubes, but this is of no consequence in the 61A1.

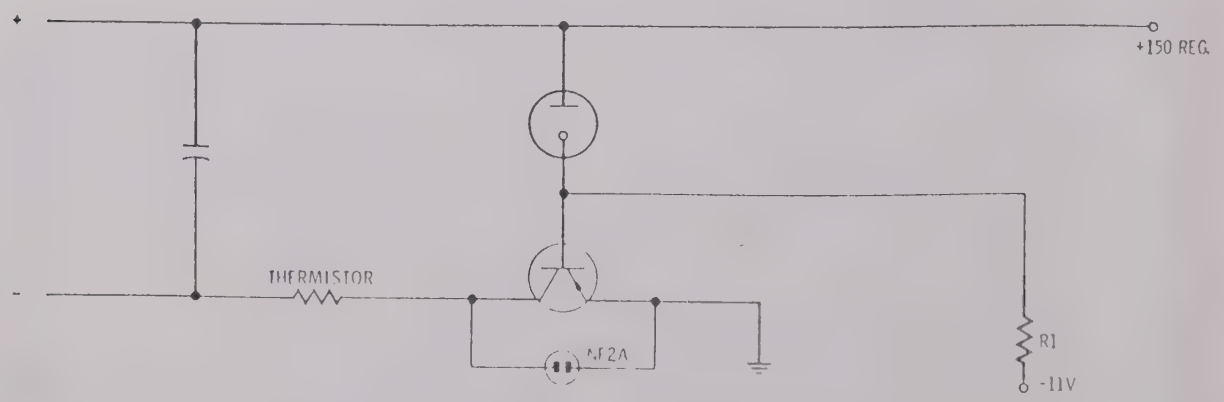


Figure 10. +150-Volt Regulator, Simplified Schematic

Operation of the filament regulator (refer to the simplified schematic, figure 11) is similar to that of a Zener diode. Load voltage is essentially a clipped sine wave. The full wave rectifier is used to simplify the circuit since the regulator output provides only one polarity waveform to be clipped. If a full wave rectified waveform is clipped off at a constant level, amplitude variations ahead of the clipper will be removed. The rms value of the waveform will still vary because the area under the remaining waveform changes slightly as the slope increases and decreases with initial peak amplitude. The lower the clipping level, relative to the peak amplitude, the less the rms variation. The process of reducing clipping level has practical limitations, however, since the clipped portion of the waveform represents lost power in the clipping device. In the 61A1 regulator, as the waveform increases in a negative direction from zero, transistor Q1 will conduct because of base drive through R1. Transistor Q2 will not conduct until the voltage at its base reaches the forward breakdown voltage of the two silicon rectifiers CR1-CR2 in its emitter return. These are low-cost silicon rectifiers whose forward drop is used for the reference. There will be no current through the rectifiers until the regulator output voltage reaches the forward breakdown voltage of the two rectifiers in series. As the input voltage continues to increase, the output voltage will follow it until Q2 conducts. As soon as Q2 conducts, the entire circuit will function as a conventional regulator, with CR1-CR2 as the reference. Regulator action will stabilize the output voltage even though the input continues to increase, and it will remain at the regulated level until the input voltage drops to the point where the circuit drops out of regulation. The output voltage will then follow the input down to zero. This action will result in the clipped waveform shown. A compensating resistor may be added (shown dotted) to improve rms regulation. As the input waveform approaches its peak, and the rms value of the output tends to increase slightly, the compensating resistor will apply additional drive to Q2 which will result in a depression or valley in the top of the clipped waveform. Any increase in input peak amplitude will tend to increase the amount of depression in the waveform and net change in the rms value can be held to a very small value. Output voltage is adjusted by setting the ratio of R3 to R4 in the feedback divider.

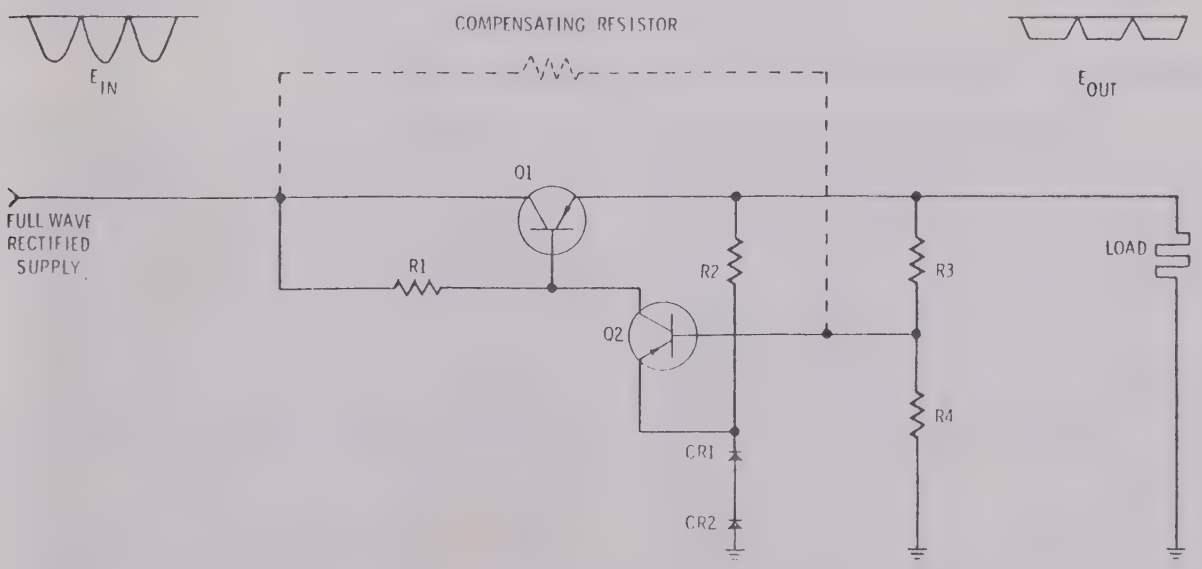


Figure 11. Filament Regulator, Simplified Schematic

OPERATION

INSTALLATION

The 61A1 is ready to operate when received from the factory. It has been fully calibrated and adjusted; only operating adjustments are required. The equipment is supplied with power supplies connected for 105-125 volt operation. If 210-250 volt operation is required, jumper connections in the power supply must be changed according to the schematic.

When the 61A1 is operated in the bench cabinet supplied, leave 5 inches or more clearance at the rear for ventilation. Do not obstruct the ventilating holes in the bottom of the case. The equipment may be rack-mounted directly by removing it from the case. The panel is a standard rack 10½-inch size, notched for standard rack mounting.

CAUTION

When operating the 61A1 outside its case, remember that the AFC deck operates at the associated klystron circuit reflector potential. If this portion of the receiver is exposed, take precautions to prevent contact.

REMOVING THE EQUIPMENT FROM THE CASE

To remove the 61A1 from its case, remove the four Phillips head screws in the trim angles on each side of the panel. Loosen the captive screw at the rear of the chassis, and slide the unit forward out of the case. To replace the equipment, reverse this procedure. The trim angles are mounted to the case by floating self-locking nuts to permit adjustment. Top and bottom trim tees are also mounted on floating nuts. It is not necessary to remove the tees to take the 61A1 out of the case and it is seldom necessary to disturb their factory adjustment.

TYPICAL SETUP

A typical setup using the 61A1 for attenuation measurement is shown in figure 12. External signal switching is shown. The only change in the setup for internal switching would be the omission of the 1-kc signal cable between the 61A1 and the Sperry *Microline* 62A1 Universal Klystron Power Supply. The oscilloscope is not absolutely essential but is an extremely valuable accessory in this or any microwave setup. Oscilloscope external sync may be obtained from the 1-kc signal used to modulate the signal klystron.

Electronic Units

The Sperry *Microline* 62A1 Universal Klystron Power Supply furnishes beam, grid, and reflector voltages for the signal and local oscillator klystrons. Signal klystron modulation is obtained from the 62A1 modulator. Regulated filament power from the Sperry *Microline* 62A2 D.C. Klystron Filament Supply contributes significantly in reducing frequency variations and incidental f-m from the klystrons. The Sperry *Microline* 62D1 Dual Klystron Adapter permits independent control of grid and reflector voltages for the two klystrons. A 1-kc square wave for signal modulation is supplied to the 62A1 from the 61A1. Local oscillator klystron power is connected to the 61A1 from the dual adapter for insertion of AFC correction voltage; the local oscillator is then connected to the 61A1. Oscilloscope monitoring of the 61A1 video output is helpful in adjustments and measurements.

Waveguide Components

The waveguide portion of the setup consists of a signal klystron, level-set attenuator, isolator, and slide-screw tuner, all of which may be considered as the *source*. The slide-screw tuner is used to tune the source group of components for Z_0, or minimum SWR. The unknown is inserted between the source group and the detector group. A slide-screw tuner and isolator are used following the unknown to tune the entire detector group of components for a match. Having a match in both directions from the unknown, insures measurement of the true attenuation of the unknown, including its mismatch losses.

Following the tuner and isolator in the detector group is a directional coupler with the LO klystron and its level-set attenuator on the side arm. Next is a frequency meter, followed by a tuner and detector mount used as a mixer. The last tuner is required since mixers are generally poorly matched to the line and additional tuning is necessary.

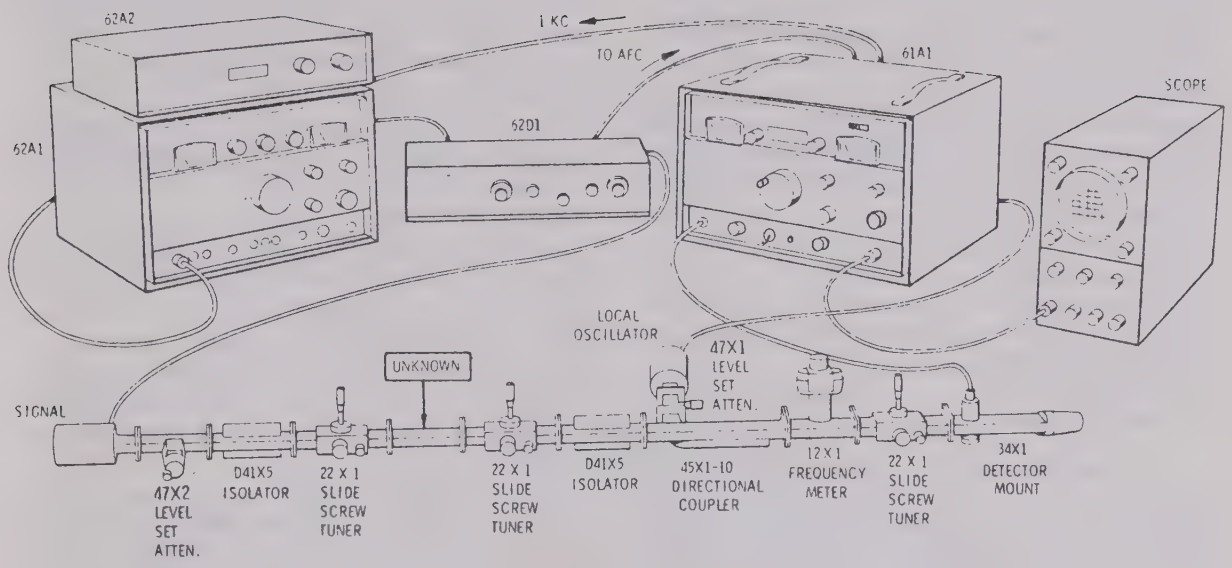


Figure 12. Typical Measurement Setup Using the 61A1

Precautions in Attenuation Measurements

A number of precautions are necessary in attenuation measurements if accurate and repeatable results are to be obtained. This is especially true with the 61A1 because of its high resolution.

The waveguide setup must be mechanically stable. Flexing or bending of the setup or components in it will cause variations in tuning and attenuation in all or part of the setup. Flanges must be straight and clean to insure good r-f continuity and minimize leakage. Critical adjustments, such as on the tuners, must have locks to prevent accidential variation. The setup must be evenly supported to eliminate mechanical strain on components and flanges. Microwave reflective surfaces in the vicinity of the setup should be avoided since such surfaces will enhance the return to the setup of any leakage which may occur.

When performing measurements in some microwave setups it may be necessary to shield the klystron cables to prevent external noise pickup. Such noise pickup may increase the receiver noise level to an extent sufficient to degrade the accuracy of low level measurements.

Tuning is very important for precise measurements. 61A1 resolution is 0.01 db and mismatch errors in the setup can exceed this very easily. Time spent in matching the setup properly is well spent if accurate measurements are to be made conveniently.

Sometimes a small amount of backlash may be encountered in an attenuator. To minimize the affects of this backlash, approach the final attenuator setting from the same direction each time a new setting is made.

When performing measurements under poor signal-to-noise ratio conditions, local oscillator tuning should be made carefully. Under these con-

ditions the signal deviation tends to be masked by the noise, causing AFC operation to be less sensitive (net discriminator output is lower for a given signal change). To minimize errors in measurement it is necessary to tune the LO frequency as close as possible before switching to AFC operation.

If the unknown is a device with fixed attenuation, the setup must be adjusted to a reference level before it is inserted. After the reference is set, the setup must be handled carefully when putting the unknown into place to avoid changing the original conditions. It may be necessary to make such a measurement several times to eliminate variations due to flange misalignment, mechanical disturbances, and minor power fluctuations. Obviously, a stable signal source is essential in any attenuation measurement.

Klystron Considerations

For maximum operational efficiency in attenuation measurements, it is essential that stable signal sources be used. The best source from an overall standpoint is a klystron. Under the proper operating conditions, klystrons generally have less incidental f-m, better frequency and amplitude stability, and more power output than any other type of source. Some of the considerations in establishing these conditions are discussed below.

Klystrons must be operated so the desired frequency falls in the center of the mode. Frequency and amplitude changes with variations and ripple in the tube supply voltages are minimum at this operating point. Although the 61A1 AFC control provides a wide range of correction voltage, errors will be smaller and results will be more nearly repeatable if the correction required is minimized. It is important that both signal and LO sources be adjusted for their proper operating conditions and AFC used as insurance. This is particularly important if measurements are being made at very low signal levels (below about -90 dbm) where there will be some uncertainty in AFC and null circuits due to noise.

Many klystrons are sensitive to physical vibration. The setup must be mounted on a solid base and supported firmly to eliminate physical shocks to the klystrons. Vibration problems may arise from the method of cooling used on the tubes. It is important that tube temperature be stabilized as much as possible. High velocity blowers frequently used with klystrons generate a surprising amount of f-m and vibration "noise" in the klystron output, even when they are separated from the tube by a flexible hose. Oil bath stabilization is much better than forced air. The most efficient cooling technique now in use is a water jacket in contact with the tube cavity. Water jackets not only give excellent temperature stabilization, but are completely free of vibration. Water jackets are available for many klystron types in the *Microline* Klystron Kooler line.

The importance of setup tuning has already been mentioned, but its effect on klystron performance should also be noted. Frequently klystrons will become unstable when presented with a mismatched load. With the setup shown in figure 12, there will usually be enough attenuation inserted in the level set attenuator to present a good match to the klystron. Except in very unusual circumstances, there will probably not be any problems in an attenuation setup with poor matches at the klystron; however, the problem should be appreciated.

If internal switching is used in the 61A1, the signal klystron operates continuously. If external switching is used, the signal klystron is square wave modulated. Modulation amplitude and reflector voltage must be adjusted for clean, stable klystron output. The klystron must be adjusted so the desired frequency falls in the mode center before modulation is applied. Subsequent modulation adjustment will bring the output back to the most stable operating point when proper operating conditions are reached.

Mixer Considerations

The entire range of the 61A1 can be covered using good single-ended mixers. Output traps are used in all *Microline* detector mounts and excellent mixer performance is obtained with the resulting low capacity. If any other manufacturer's mount is used, it should be checked to be sure it is a low capacity type or conversion loss will be excessive.

Some mixer crystal types will show a considerable range of conversion loss and noise figure. If difficulty is experienced in low level measurements, several mixer crystals should be tried. The average crystal is satisfactory for full range measurements, but it is not unusual to find one which gives marginal mixer performance.

Measurement range can be extended slightly on the upper end by increasing the local oscillator level and on the lower end by decreasing the local oscillator level. The total measurement range

(100 db) will remain the same, only the ends are shifted one direction or the other. Note that the local oscillator level increase is limited by crystal burnout and the decrease is limited by the measurement errors which can be tolerated.

The receiver range, with respect to the mixer input power level, shifts with conversion loss. If the upper end of the range is fixed by the local oscillator level, poor mixer noise figure may prevent realization of the full 100-db range because the low levels cannot be reached.

Certain mixers may provide outputs which do not match the absolute level output range of the attenuator. The reference channel of the 61A1 is designed for a specific input voltage range, not a power level. For a 100-db power range at the mixer input, an exceptionally good mixer may provide an i-f signal range above the receiver range. In this case the i-f range is 100 db, but it may not coincide with the attenuator range.

OPERATING CONTROLS

The following are front panel operating controls (refer to figure 13).

1	OUTPUT	Meter indicates mixer crystal current, output (VTVM reading), or AGC control voltage. Polarity of the crystal current is determined by the XTAL CURRENT-OUTPUT switch
2	XTAL CURRENT-OUTPUT	Switch selects function for OUTPUT meter
3	FREQUENCY DEVIATION	Indicates correction voltage on AFC which corresponds to frequency deviation in input signal
4	AFC ZERO	Zero adjustment on phase modulator in AFC amplifier
5	NULL	Meter indicates null balance on comparison mode
6	X1 - X10	Switch selects null sensitivity for most convenient measurement. In the X10 position, sensitivity is reduced 10 times
7	ATTENUATOR	30-mc attenuator
8	DB	Indicates setting of attenuator
9	GAIN	Adjusts gain of i-f strip in linear and a-c operation
10	AFC	Selects AFC off, + or − internal, or + or − external
11	OUTPUT SWITCH	Selects linear, log, or a-c indication on OUTPUT meter
12	MODE SWITCH	Selects reference oscillator, straight receiver, or comparison operation. Switching to comparison (COMP) automatically places i-f strip on AGC and switches output meter to indicate AGC voltage
13	AC VIDEO	A-c video output from i-f strip from cathode follower
14	NULL ZERO	Zero adjustment on NULL VTVM

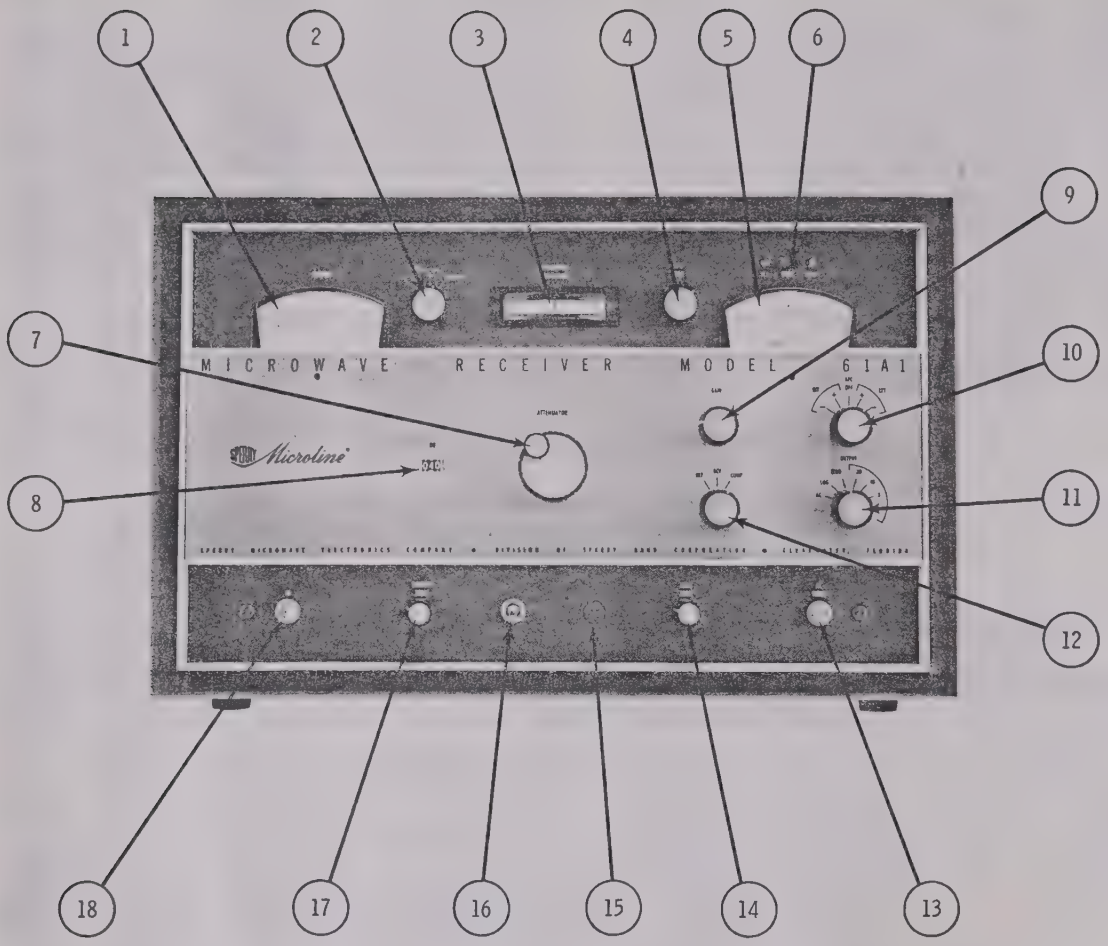


Figure 13. Front Panel Operating Controls

15	POWER	Indicator light for a-c power
16	POWER SWITCH	Controls application of a-c power to 61A1
17	OUTPUT ZERO	Zero adjustment on OUTPUT VTVM
18	IN	30-mc input to receiver

The rear of the 61A1 with its operating controls is shown in figure 14

1	KLYSTRON POWER	Output connector for AFC corrected voltage to the klystron
2	KLYSTRON POWER INPUT	Input connector from the klystron power supply
3	2 AMP SLOBLO	Power line fuse
4	SWITCHING	Selects internal or external switching mode
5	AFC GAIN	Permits adjustment of AFC loop gain to prevent oscillation
6	RECORDER	Output jack for 1-ma, 1500-ohm graphic recorder, one side ground, connected in VTVM for OUTPUT meter. Recorder circuit not affected by switching OUTPUT meter to XTAL CURRENT
7	DC VIDEO OUTPUT	Direct output from i-f strip video detector
8	EXT AFC	Input jack for AFC control from external source
9	1 KC OUT	1-kc square wave output for scope sync and external switching signal
10	30 MC OUTPUT	Approximately 2.35 volts output from 30-mc reference oscillator

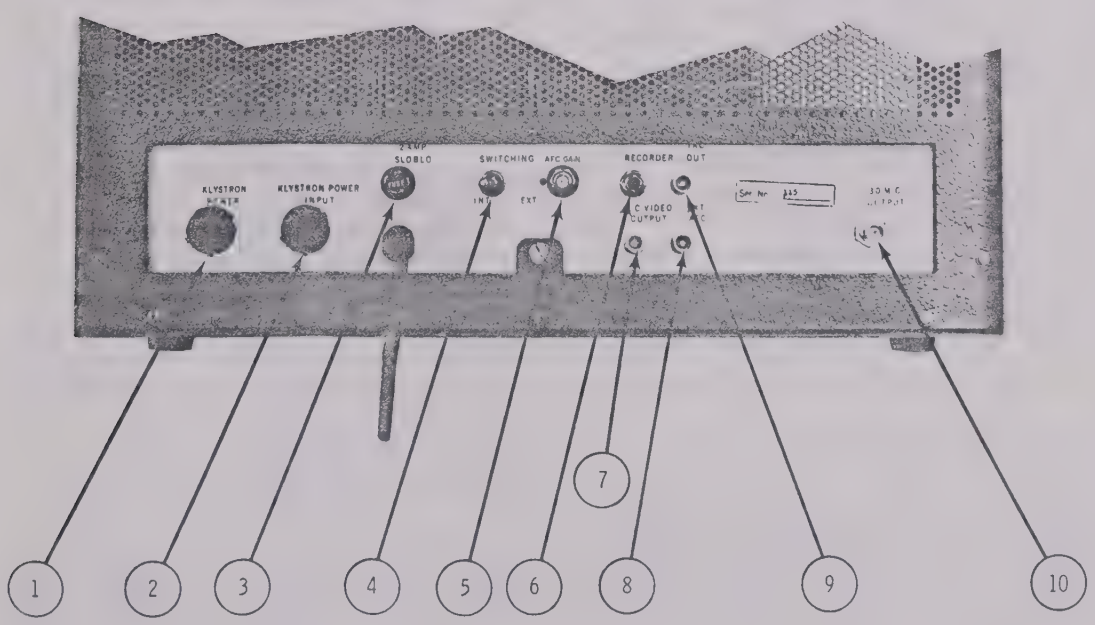


Figure 14. Rear Panel Operating Controls

INTERCONNECTION OF EQUIPMENT

Refer to figure 12 for a typical setup using the described interconnections. The 62A1 and 62A2 are connected for d-c filament operation and the output is connected to the 62D1 input. One output from the 62D1 is connected to the signal klystron and the other to the KLYSTRON POWER INPUT socket on the 61A1 rear chassis. Local oscillator klystron power is obtained from the KLYSTRON POWER jack on the 61A1 rear chassis. This connection inserts the 61A1 AFC adapter into the local oscillator supply.

If external switching is used, S606 (SWITCHING) on the 61A1 rear chassis is set to EXT and a connection is made from the 1 KC OUTPUT to the EXT MOD jack on the 62A1. This applies a 10-volt p-p 1-kc square wave to the 62A1 modulator input and the AMPL EXT output will furnish ample modulating voltage for the klystron. If internal switching is used, the signal klystron is operated c-w and this connection is omitted. S606 (SWITCHING) on the 61A1 rear chassis is set to INT for internal switching operation.

A dual shielded cable is supplied with the 61A1 for connection between the mixer and the input jack. The 61A1 is tuned for use with this cable and a low-capacity mixer such as the *Microline* series. If another cable is used, it must be of a dual shielded type since leakage or pickup in the input cable will introduce errors into the measurement, particularly at low levels. Use of cables having different capacity from the one supplied will detune the input circuits slightly. There will be little noticeable effect on performance, however, except at very low signal levels.

The signal for oscilloscope monitoring is available at the AC VIDEO jack on the 61A1 front panel. For convenience, it is recommended that the signal from the 1 KC OUTPUT jack on the 61A1 rear chassis be used for oscilloscope external sync.

PRELIMINARY ADJUSTMENTS

A warmup period of about 15 minutes is advisable before operating the 61A1. After warmup, the following adjustments should be made (refer to figures 13 and 14). Adjustments are listed for internal switching (S606 on INTERNAL), but there are no significant changes in procedure for external switching. Special considerations for external switching are given after adjustment descriptions.

1. Set S604 to OUTPUT, S605 to ZERO and adjust R610 (OUTPUT METER ZERO) for zero indication on the OUTPUT meter.
2. Set the NULL sensitivity switch, S607, to the X1 position.
3. Rotate the AFC GAIN potentiometer, R605, on the rear chassis to the maximum clockwise position.
4. With S603 in either RCV or REF, adjust R604 (NULL METER ZERO) for zero indication on the NULL meter.
5. Set S603 in COMP, S602 (AFC) to EXTERNAL + or − and check FREQUENCY DEVIATION meter for zero indication.
6. With S602 in an EXTERNAL position, switch S603 to RCV and adjust R602 (AFC ZERO) for zero indication on the FREQUENCY DEVIATION meter.

Klystron frequencies should now be set. A frequency meter should be used to insure that the frequency difference between tubes is actually 30 mc. A 30-mc i-f strip will respond to submultiples of 30 mc and assorted spurious responses may be generated in the mixer from other frequency combinations as well. Once the frequencies are set to an approximate 30-mc difference using the frequency meter with the klystrons set to the center of their modes, final adjustment may be made using the receiver. The 61A1 XTAL CURRENT position of the OUTPUT meter may be used for a tuning indicator and to observe the frequency meter dip during preliminary adjustment. After this has been done, back off the signal klystron power and adjust the LO level for 1.5 ma mixer current as read on the 3 scale of the OUTPUT meter with S604 in XTAL CURRENT position. Make final frequency adjustment as follows:

1. Set S604 to OUTPUT, S603 to RCV, S602 to OFF, S605 to 30, R603 (GAIN) to maximum CW, apply a signal from the klystron, and adjust the reflector voltage on the LO klystron for indication on the OUTPUT meter. If the frequencies have been set carefully with the frequency meter, it should not be necessary to adjust it very far.
2. After adjusting the LO reflector voltage so the OUTPUT meter indication is approximately maximum, final reflector adjustment is made watching the FREQUENCY DEVIATION meter. Adjust LO reflector voltage for zero indication

on the FREQUENCY meter. At the proper adjustment, a small reflector voltage change in one direction should cause a rapid change in FREQUENCY DEVIATION reading and a small change in the other direction should cause a rapid change in reading in the other direction. When making measurements below about -90 dbm, noise is present in the AFC system. It is necessary to set the klystron frequency as close as possible to zero indication on the FREQUENCY DEVIATION meter (with AFC off) to minimize the effect of AFC noise. The frequency can be adjusted at a low level, around -70 dbm or so, and the adjustment will hold throughout the range.

3. Switch S602 (AFC) to INTERNAL + or INTERNAL −, depending on whether the LO is above or below the signal. If the local oscillator is below, AFC will hold on INTERNAL −, and vice versa. It will be fairly obvious that the AFC has locked on by observing the FREQUENCY DEVIATION meter action; it should indicate near zero after it has locked in. If the FREQUENCY DEVIATION meter indication oscillates, reduce the AFC loop gain by rotating the AFC GAIN control counterclockwise until the oscillation ceases.
4. Switch S603 to COMP; the AFC should still be locked on and indicate very near zero. The equipment is now ready for measurements.

OPERATING ADJUSTMENTS

The table below gives a summary of control positions for various operations with the 61A1 during measurements.

	OPERATION	SWITCH POSITIONS	ADJUSTMENT	INDICATION
1	Check AFC power supply zero	AFC: EXT + or EXT − COMP (S603)	R209 (Internal)	Zero on FREQUENCY DEVIATION meter
2	AFC ZERO	AFC: EXT + or EXT − RCV (S603)	AFC ZERO	Zero on FREQUENCY DEVIATION meter
3	Check mixer current	XTAL + or XTAL −	LO attenuator	1.5 ma on 3 scale of OUTPUT meter
4	Initial setup, straight receiver	AFC OFF RCV (S603) OUTPUT (S604) 30 (S602) GAIN max. CW	Signal reflector LO reflector for Final LO adjustment	Center of mode Max. OUTPUT ind. Zero on FREQUENCY DEVIATION meter
5	Check LO frequency	XTAL + or XTAL −	Frequency meter	Dip on crystal current
6	Check signal frequency	AFC INT + or INT − OUTPUT (S604) 30 (S602) GAIN for convenient OUTPUT indication RCV (S603)	Frequency meter	Dip on OUTPUT
7	Attenuation measurement	AFC INT + or INT − COMP (S603)	ATTENUATOR	Zero on NULL meter
8	Zero OUTPUT VTVM	ZERO (S602)	OUTPUT METER ZERO	Zero on OUTPUT meter
9	Zero NULL VTVM	RCV (S603)	NULL METER ZERO	Zero on NULL meter

If external switching is used, it will be necessary to adjust the signal source for proper modulation before the final adjustment above. It must be modulated cleanly and be in the proper phase with respect to the 61A1 reference oscillator modulation. When a klystron is used, phase of the modulation will change 180° when reflector voltage is switched from one side of a mode to the other side of the same mode. In signal generators, a phase reversal switch is frequently included for the modulation. Signal modulation must be such that the signal and reference oscillator are on alternately. Modulation waveform may be observed by operating the 61A1 in the RCV position and displaying the a-c output on an oscilloscope. If the scope is synchronized with the 1-kc output from the 61A1, phase of the signal modulation with respect to the reference is easily determined. Once the user has become accustomed to operation of the 61A1, it will be immediately apparent if the signal is not in proper phase.

Final tuning on the detector mount mixer should be for the maximum 30-mc output signal. Usually, there will be a slight difference in tuning between maximum LO mixer current and maximum i-f signal out. If measurements are being made to low levels, it is important that i-f output from the mixer be maximized.

TYPICAL MEASUREMENTS

Several typical measurements are described below to outline a few complete procedures in making measurements with the 61A1.

Attenuation

The setup is first made as shown in figure 12 but without the unknown in place. It is assumed that necessary tuning adjustments have been made. It is also assumed that VTVM and AFC zero adjustments have been made.

1. Check XTAL CURRENT for 1.5 ma.
2. Check AFC tuning by switching AFC to OFF. If necessary, adjust LO reflector for FREQUENCY DEVIATION reading near zero. Turn AFC on.
3. Set ATTENUATOR to 20.00 db. This places the receiver in its most accurate range if the unknown is between 0 and 60 db.
4. Turn S603 to COMP, S604 to OUTPUT, and adjust signal level for zero on the NULL meter. This establishes the reference level.
5. Insert the unknown into the microwave setup. Care should be exercised to minimize physical shock to the setup and components while doing this. It may be helpful to use a section of guide in place of the unknown while setting up the reference level to minimize rearrangement of the setup when inserting the unknown later.
6. After the unknown is in place, adjust the ATTENUATOR for zero indication on the NULL meter. The ATTENUATOR is always turned in a direction to bring the NULL meter back on scale. That is, if the NULL meter is off scale to the left, turn the ATTENUATOR to the right. After the new null is established, read the ATTENUATOR dial.
7. Subtract the initial reading (20.00) from the new reading. The difference is the attenuation of the unknown. It may be desirable to repeat the measurement once or twice if extreme accuracy is desired. Variations in mechanical connections and slight power variations may be eliminated by taking several measurements and averaging the results. If the unknown exceeds 60 db, it is advisable to repeat the measurement starting at a higher level, say 10.00 db.

Absolute Power Level

Since the reference oscillator signal in the 61A1 is applied to the i-f strip after the mixer, it is an indication of 30-mc i-f output signal from the mixer. Actual r-f power level applied to the mixer may be measured by calibrating the mixer and 61A1 together. If a Sperry *Microline* 34( )1 detector mount is used as the mixer, the mixer crystal may be removed and a barretter inserted directly. A power meter may be connected to the mount and a level (1 mw is convenient) set up. The mount must be retuned with the barretter since it will present a different match to the system from the crystal. After the reference level is established, the crystal is replaced and the mount retuned. Maximum level for the 61A1 is nominally -10 dbm in the guide, so the reference power must be reduced by a known

amount to fall within the 61A1 range. A calibrated variable attenuator or a fixed attenuator may be inserted in the setup and the 61A1 ATTENUATOR adjusted for null indication. With an initial level of 1 mw, if the 61A1 indicates a null at 5.00 on its attenuator with 20 db of attenuation inserted in the setup, then 5.00 corresponds to -20 dbm. This calibration holds for the mixer and frequency used for the calibration. If the mixer or frequency is changed, the conversion gain of the system may also change and a new calibration is required. The attenuator inserted to reduce the level may be measured with the 61A1 so the power reduction from the initial level is known very accurately. The entire power measurement will then depend on the accuracy of the equipment used to set up the initial power level.

1. With the setup as in figure 12, replace the mixer crystal with a barretter.
2. Connect a power meter, such as the Sperry Microline Model 31A1 Average Power Meter, to the Sperry Microline 34X1 Detector Mount. Remove all r-f power and zero the meter.
3. Apply power from the signal klystron only until an indication is obtained on the power meter. Tune the 34X1 for maximum indication. Adjust the power level to 1 mw.
4. Remove the power meter and barretter and replace the mixer crystal. With S604 in XTAL CURRENT, tune the Sperry Microline 34X1 Detector Mount for maximum crystal current.
5. If a fixed attenuator is used, insert it at the point marked UNKNOWN in figure 12.
6. Adjust LO output for 1.5 ma crystal current.
7. Set S604 to OUTPUT, S603 to RCV, S605 to 30, and adjust GAIN for convenient indication on the OUTPUT meter. Readjust the 34X1 for maximum indication.
8. Set S603 to COMP and adjust the ATTENUATOR for zero on the NULL meter. Subtract the ATTENUATOR reading from the db loss in the fixed attenuator in (5) above. The difference is the 000.00 power level for the 61A1 -dbm.
9. If a variable attenuator is used in (5) above, it should be set to maximum attenuation when inserted. In (8), set the 61A1 ATTENUATOR to 000.00 and adjust the variable attenuator for zero on the NULL meter. The attenuator reading is the 000.00 power level for the 61A1 in -dbm.
10. If the 000.00 setting corresponds to -12 dbm for a given setup, then a null at 16.40 db on the ATTENUATOR indicates a signal level at the mixer of 16.40 db below -12 dbm, or -28.40 dbm.

Signal Generator Calibration

Output attenuator calibration for signal generators is easily accomplished with the 61A1. If the 61A1 power level calibration above is performed, output power level can be checked simultaneously. If a 30-mc generator is being checked, no mixer is required. The setup of figure 12 may be used with an appropriate connection between the generator and the guide. Components required in the setup for matching the unknown may be omitted. After the generator and setup are adjusted for the desired operating frequency, set the 61A1 for proper AFC operation and comparison operation.

1. Set the generator output at the highest level to be used. If this exceeds the 000.00 level of the 61A1, insert attenuation between the generator and mixer for zero indication on the NULL meter. If the level is less than the 000.00 level, adjust the ATTENUATOR for zero on the NULL meter.
2. Advance the signal generator attenuator to the first calibration point.
3. Adjust the ATTENUATOR for zero on the NULL meter. Subtract the previous ATTENUATOR reading from the reading obtained with this null. The difference is the attenuation inserted.
4. Repeat (2) and (3) for subsequent points as desired.
5. If the power limit of the 61A1 range is reached and additional points are desired at lower levels, attenuation inserted in (1) above may be removed and the ATTENUATOR readjusted for a null. Additional measurements may now be made from this new reference point. If no attenuation was inserted in (1), the lower limit of calibration with the 61A1 has been reached.

Log Operation

The 61A1 may be used as a straight log response receiver if desired. Set S604 to OUTPUT, S603 to RCV and S605 to LOG. The 61A1 gain is set automatically when S605 is set at the LOG position and the OUTPUT meter log scale is used for readout. Log response is accurate to 3% or better. The meter scale is calibrated from full scale downward to facilitate use for antenna patterns or similar response measurements. A recorder jack is supplied on the 61A1 rear chassis for graphic recorder use in these measurements.

Linear Operation

For linear receiver operation of the 61A1, set S604 to OUTPUT, S603 to RCV, and S604 to the VTVM scale desired. Four full-scale ranges, 1, 3, 10 and 30 volts, are provided. The VTVM indicates the d-c voltage at the i-f video detector. I-f strip gain is controlled with the GAIN control. With the GAIN control maximum CCW, approximately 0.1 volt at 30 mc is required at the input jack to produce 30 volts d-c at the video detector.

A-c voltage at the i-f video output is indicated on the OUTPUT meter in the AC position of S604. Full scale sensitivity is -10 volts rms.

External AFC

External AFC control may be used with the 61A1 by applying the external control voltage to the EXT AFC jack on the 61A1 rear chassis. Approximately 1 volt is required for 25 volts change at the klystron circuit. Polarity of external AFC can be selected from the front panel.

Low Level Receiver Operation

If the 61A1 is used as a straight receiver at low levels, the ATTENUATOR must be turned to maximum reading. The reference oscillator diode output switch inserts approximately 60-db isolation. The reference signal will be approximately 60-db below the ATTENUATOR reading and may interfere with low level receiver operation if high attenuation is not used.

ACCURACY TABLES

The table below relates 61A1 measurement accuracy to input signal level. Inspection of this table will assist the operator in selecting a measurement range which will give the most accurate results.

ACCURACY TABLE

Total Single Step, db	Starting Level dbm	Max. ±db Error for Single Step
1-10	-25	0.06
10-20	-25	0.07
20-30	-25	0.08
30-40	-25	0.10
40-50	-25	0.11
50-60	-25	0.13
60-70	-20	0.16
70-80	-20	0.19
80-90	-15	0.28
90-100	-10	0.49

MAINTENANCE AND ADJUSTMENT

GENERAL INFORMATION

The 61A1 has been designed for adjustment with a minimum of external test equipment. In general, a VTVM and oscilloscope will be adequate for complete adjustment of the unit. When making an adjustment, be sure adjustments preceding it in this section have been made. Refer to figures 15 and 16 for the location of internal adjustments.

The Sprague Microline 46B1 Precision I.F. Attenuator is used to attenuate 30-mc signals by an accurately known value over a continuously adjustable 100-db range. Refer to the instruction sheet at the end of this section for maintenance and adjustment for the attenuator.

If the i-f strip is operated for extended periods of time with excessive output signal levels (40-45 volts) the dissipation ratings of some components may be exceeded, causing damage to the i-f strip. When the equipment is turned on but not used for measurements, reduce the signal level applied to the receiver.

When replacing parts in the 61A1, do not change ground points. Relocation of ground points may increase the receiver noise level, degrading the accuracy of low level measurements. Dress leads and replacement parts in the same fashion as the original part to maintain original circuit balance and performance.

When replacing mixer crystals it may be necessary to select and match crystals to obtain good performance. Some crystals may possess an impedance which is too low and results in insufficient coupling. Some crystals may provide a poor noise figure which may limit the low level measurement capability; other crystals may have excessive conversion losses causing a shift in the range of the receiver. If a particular crystal exhibits any of these characteristics, try several other crystals before attempting a realignment of the receiver.

ADJUSTMENTS

+150-Volt Supply

The +150-volt supply consists of a bridge rectifier, capacitor input filter, OA2 150-volt reference, and gate transistor. Output voltage is determined directly by actual VR tube operating voltage, which may vary approximately ±10% about 150 volts with different tubes. Supply regulation is approximately ±0.5% with 10% line change. No voltage adjustment is provided for this supply since regulation is of primary importance and actual output voltage is not critical.

−11-Volt Supply

The −11-volt supply output is regulated by a ±20 percent tolerance Zener regulator, VR1. No adjustment is provided.

Regulated Filament Supply

The 61A1 filament regulator operates as an automatic clipper and produces a clipped full wave rectified sine wave. The filaments respond to the rms value of this waveform and adjustment is made for the equivalent average voltage corresponding to 6.3 volts rms.

1. With the receiver operating in any mode, measure the voltage from the emitter of Q1 to ground with an average reading voltmeter. An ordinary multimeter or VTVM is satisfactory.
2. Adjust R5 on the terminal board for 5.9 volts dc as indicated by the average reading meter. This corresponds to 6.3 volts rms.

Reference Oscillator

1. Set S603 to REF, S605 to 30, ATTENUATOR to approximately 60, and adjust the GAIN control for a convenient indication on the OUTPUT meter.
2. Adjust L101 and L102 on the reference oscillator box for maximum indication on the OUTPUT meter. Adjustment of L101 may show a sharp drop in output on one side of maximum. If it does, set it for output slightly below maximum on the side away from that which gives the sharp drop. This is a normal condition with crystal oscillators.
3. Adjust R105 for 2.2 volts rms as measured at the 30 MC OUTPUT jack. Note that the voltage at the attenuator is 2.35 volts rms due to the transmission line effect in the cable from the attenuator to the output jack.

1-Kc Oscillator

1. Measure the 1-kc output voltage at the top of R311 and adjust R306 for 9 volts peak-to-peak (3.18 volts rms).

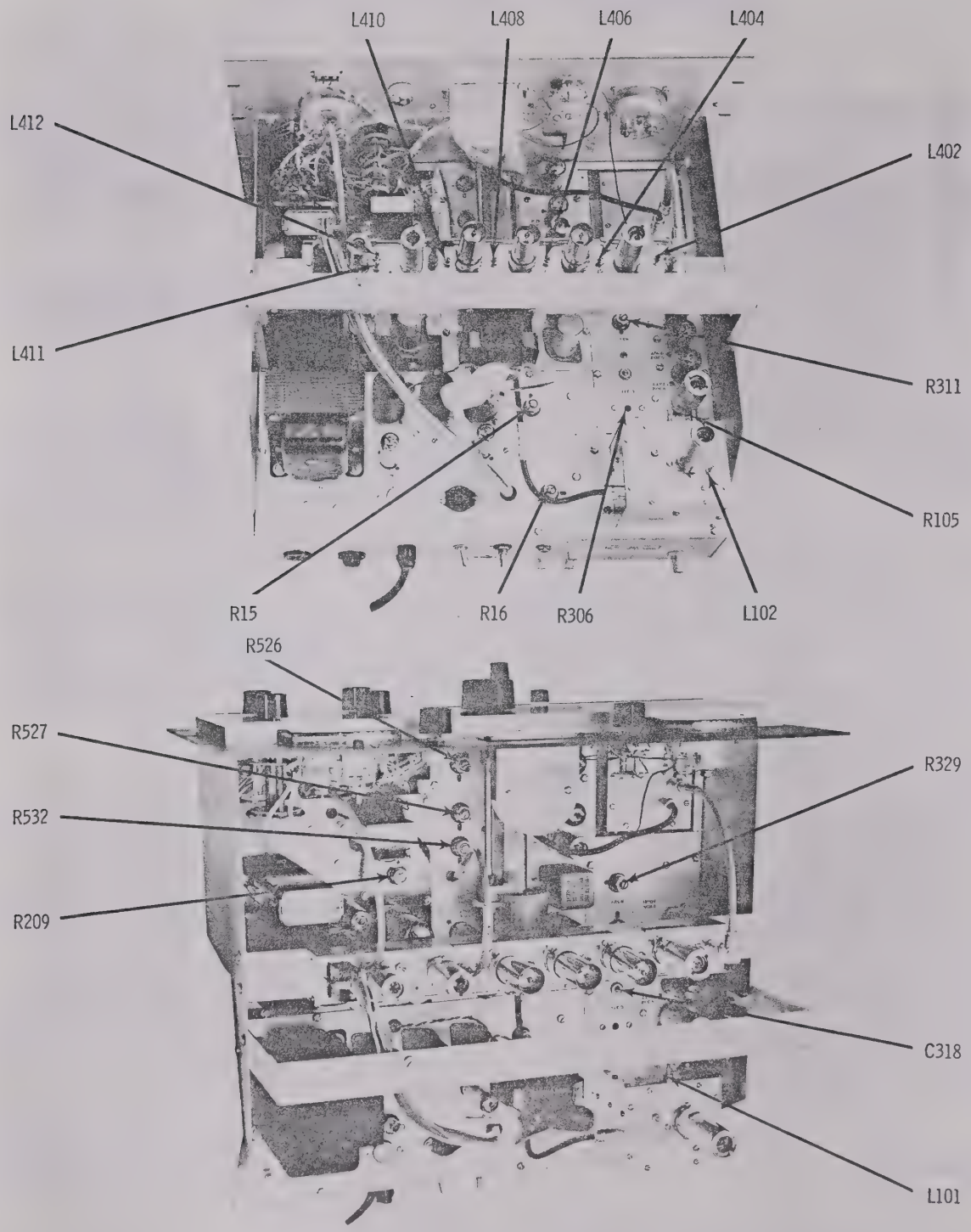


Figure 15. Location of Internal Adjustments, Top View

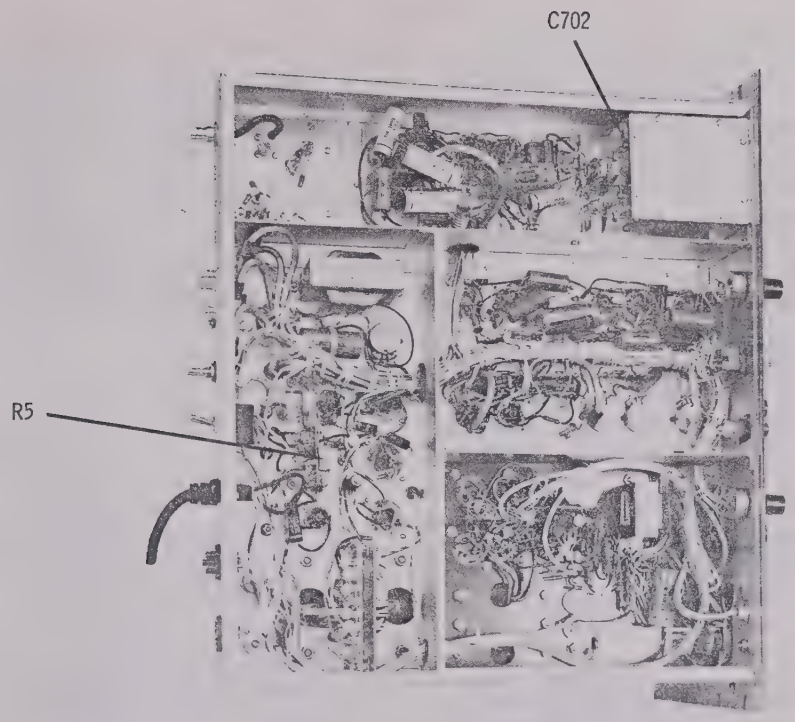


Figure 16. Location of Internal Adjustments, Bottom View

2. Check the square wave symmetry by observing the output at J604 (1 KC OUTPUT).
3. With S603 in COMP, adjust the ATTENUATOR for a clean undistorted sine wave at pin 6 of V504. Adjust C318 for maximum amplitude. If necessary, readjust the ATTENUATOR to prevent waveform distortion.
4. Synchronize the oscilloscope from the 1 KC OUTPUT jack (J604) and calibrate the oscilloscope trace by observing the square wave at the 1 KC OUTPUT jack. Note the position of the crossovers on the waveform and the polarity. Now observe the sine wave at pin 6 of V504 and adjust C318 so the sine wave crossovers match the square wave crossover points exactly. Phase response of the tuned circuit Z501 varies with frequency and slight frequency adjustment may be used to obtain exact phase matching between the i-f output signal and the reference signal to the phase detector. At proper adjustment, the audio oscillator frequency will be very close to the maximum response point of (3) above. This adjustment is made with more convenience and precision using a dual trace oscilloscope. The two signals may be displayed simultaneously and matched in phase with a minimum of error.

Square Wave Symmetry

Observe the square wave at the 1 KC OUTPUT jack (J604) and adjust R311 for equal positive and negative periods. Audio oscillator output must be 9 volts peak-to-peak before making this adjustment.

Output VTVM Calibration

1. Set S603 to REF, S605 to ZERO, S604 to OUTPUT and adjust the OUTPUT ZERO for zero indication on the OUTPUT meter.
2. Switch S605 to 1, GAIN to maximum CCW and adjust the ATTENUATOR for 1 volt d-c output from the i-f strip as measured with a VTVM at the DC VIDEO jack (J607) at the chassis rear.
3. Adjust R527 for a 1-volt indication on the OUTPUT meter.

AGC Threshold

1. Set S603 to COMP, S604 to OUTPUT, ATTENUATOR to maximum counter reading, and adjust R526 until an indication is obtained on the OUTPUT meter.
2. Adjust R526 until the indication *just* reaches zero.

NOTE

Some units may show a tendency toward oscillation (indicated by a periodic swing of the OUTPUT meter when a small signal is applied) with the adjustment as described. If this should occur, readjust R526 slightly until the AGC indication on the OUTPUT meter is slightly above zero or until the oscillation stops. When the adjustment is made properly, there will be no unstable conditions in the AGC.

AFC Power Supply Zero

Set the AFC switch (S602) to EXT, either + or −, S603 to COMP, and adjust R209 on the AFC deck for zero indication on the FREQUENCY DEVIATION meter.

I-f Strip Alignment

This alignment procedure includes adjustment of the input switch. A warmup period of approximately 30 minutes should be allowed before adjustment. Warmup should be done with the AFC switch (S602) in the EXT position, either + or −.

1. Terminate the 61A1 input with 400 ohms shunted by 35 pf. The termination must be well shielded in minimize external pickup.
2. Set S603 to RCV, GAIN to maximum CW, S605 (OUTPUT) to 3, S604 to OUTPUT, and the ATTENUATOR to maximum reading. Note the indication due to noise on the OUTPUT meter, M602. It should be about 1.4 volts.
3. Set S603 to REF, S605 to 10, and increase the signal from the reference oscillator by decreasing the ATTENUATOR reading until the OUTPUT meter indicates a video level of 7 volts.
4. Adjust L410, L408, L406, L404, and L402, in the order given, for maximum indication on the OUTPUT meter. Readjust the ATTENUATOR if necessary to maintain the video output as indicated on the OUTPUT meter at 7 volts.
5. Repeat the adjustment at least once.
6. While maintaining the video output at 7 volts as indicated on the OUTPUT meter, adjust L411 for maximum output as measured with a VTVM at J404.
7. Set S605 (OUTPUT) to 30. Increase the input signal level by decreasing the ATTENUATOR reading until the video output, as indicated on the OUTPUT meter reaches 30 volts, then adjust L412 until the voltage at J403 reaches zero.
8. Remove the 30-mc signal by disconnecting the cable at the rear of the attenuator. Readjust L411 for zero at J403. Adjust the ATTENUATOR for maximum reading and reconnect the cable at the rear of the attenuator.
9. While monitoring the voltage at J403 with a VTVM and observing the OUTPUT meter, gradually increase the input signal by decreasing the ATTENUATOR setting. The voltage at J403 will swing both positive and negative from the zero point. If the voltage swing, either positive or negative, exceeds 100 mv at any point before the video output indicated on the OUTPUT meter reaches 30 volts, L412 must be adjusted for a compromise. Adjust the input signal to provide the maximum swing at J403, but do not exceed 30 volts on the OUTPUT meter. Adjust L412 to decrease the voltage at J403 to 100 mv or less. Repeat the procedure to make certain that the voltage swing does not exceed 100 mv. Positive and negative voltage swing should be equalized approximately when adjusting L412 in this step. If both the positive and negative voltage swings exceed 100 mv, the i-f strip must be realigned.

NOTE

Occasionally, 6AL5 tubes will be encountered which show a considerable offset between halves. With such tubes in the i-f strip discriminator, it may be extremely difficult to realize the proper adjustment. The tube may be detected by removing the limiter, V405, from its socket and noting the discriminator output voltage. If it exceeds 20 or 25 millivolts, replace the 6AL5 with one which is better balanced.

10. Set switch S603 to REF, S605 to 30. Adjust the ATTENUATOR through its range. The FREQUENCY DEVIATION indication may vary

slowly from zero on either side by several divisions. This is normal and does not affect operation of the receiver. Variation is caused by slight unbalance with level changes in the discriminator diodes.

11. Adjust the ATTENUATOR to maximum counter reading, set switch S606 to INTERNAL, check the NULL ZERO adjustment, and set S603 to COMP. Adjust C702 (accessible through the rear of the input switch box under the chassis) for zero indication on the NULL meter. Recheck this adjustment after the null detector zero adjustment described below.

Null Detector Zero

1. Set switch S603 to RCV or REF and adjust the NULL ZERO for a zero indication on the NULL meter (NULL switch in the X1 position).

2. Remove V101 from its socket, switch S603 to COMP, S606 to EXT, and adjust R329 for zero indication on the NULL meter. For this procedure the 61A1 IN jack must be terminated with 400 ohms shunted by 35 pf as described under the i-f strip alignment procedure. Recheck the NULL compensation adjustment by repeating the procedure in step 11 of the i-f strip alignment procedure.

Log Adjustment

1. Set R15 to maximum CW and R16 to maximum CCW.
2. Set S605 to LOG and apply a 30-mc signal to the input jack on the front panel. Adjust the signal level for a full scale indication on the OUTPUT meter.
3. Reduce the input signal level 20 db. Adjust R15 for a 20 db indication on the OUTPUT meter.
4. Reduce the input signal level to 50 db below the original signal level. Adjust R16 for a 50 db indication on the OUTPUT meter.
5. Repeat steps 3 and 4 above several times to minimize the interaction between the two adjustments.

AC Amplitude on VTVM

With switch S605 set to AC, apply 10 volts rms, 1000 cps to the DC VIDEO jack (J607) and adjust R532 for a full scale indication on the OUTPUT meter. Measure the output at the AC VIDEO jack on the front panel with a VTVM. The output should be approximately 8 volts.

Replacing I-f Strip Tubes

If tubes in the i-f strip are replaced, it is recommended that tubes made by the manufacturers listed in the parts list be used. This is particularly true of the input cascode tube. If tubes from another manufacturer are used, it may be necessary to select 6DJ8's to obtain the specified receiver noise figure.

SWITCH FUNCTIONS (See figure 17)

Range Switch

S605A Switches multiplier on output vtvm. Automatically sets voltmeter sensitivity on LOG. Switches to a-c rectifier in AC.

S605B Grounds i-f strip grid return in all but LOG position. Grounds cathode return in LOG.

S605C Disconnects log network when not in LOG position.

Function Switch

S603A Connects null detector output to null vtvm in COMP position and grounds null vtvm input on RCV and REF.

S603B In COMP, connects switching diodes to 1 kc source. In RCV, lets signal switch open and turns off reference switch. In REF, turns on reference switch and biases signal switch off.

S603C In COMP, removes short circuit across coupling capacitor and gives a-c coupling in the AFC signal to the AFC phase modulator. In REF and RCV, the coupling capacitor is bypassed, giving d-c coupling.

S603D In COMP, grounds signal grid of AFC phase modulator. In REF and RCV, applies 1 kc signal to signal grid.

S603E Applies +150 to null signal amplifier in COMP and removes it in REF and RCV.

S603F Connects OUTPUT meter to read AGC voltage in COMP and to read output vtvm indication in REF and RCV.

S603G Switches i-f strip cathode return line to AGC line in COMP and connects it to S605B in REF and RCV.

S603H Connects i-f grid bias line to ground in COMP and to S605C in REF and RCV.

SPERRY Microline®

INSTRUCTION SHEET

46B1 PRECISION I. F. ATTENUATOR.

APPLICATION

- Full 100 db continuous attenuation range above minimum insertion loss.
- Counter readout with 0.01 db resolution and 0.05 db/10 db accuracy.

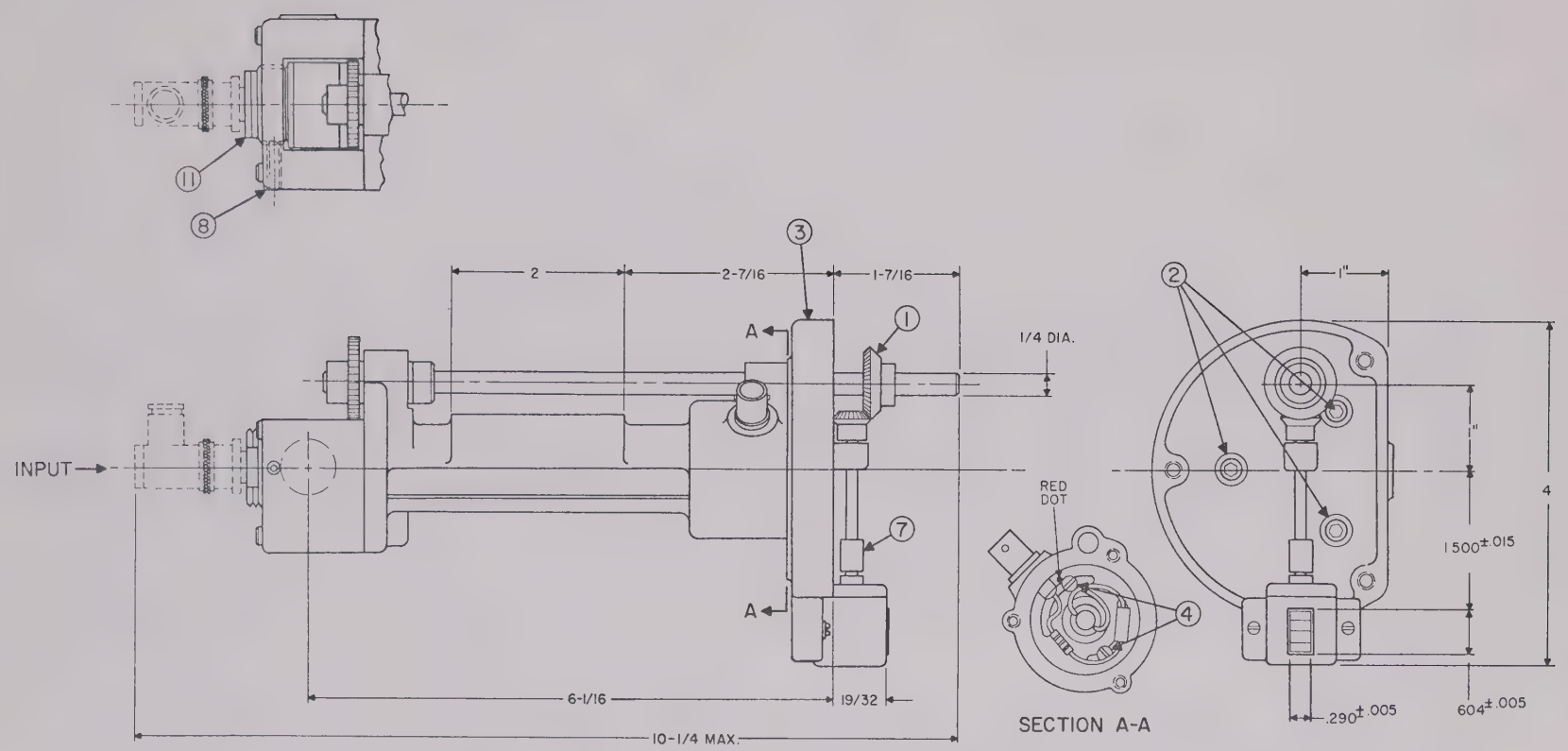
The Microline 46B1 Precision I.F. Attenuator is used to attenuate 30 Mc signals by an accurately known value over a continuously adjustable 100 db range. The unit is of the waveguide-below-cutoff type and operates in the TE_{11} mode in 0.5000 inch circular waveguide. The Microline 46B1 is designed for operation at 30 Mc and includes a 4 digit counter readout with 0.02 db least division (interpolate to 0.01 db). The initial insertion loss is 23 db with the counter set to 000.0. The incremental accuracy is 0.05 db/10 db with a maximum cumulative error of less than 0.1 db over the full 100 db range. The maximum power handling capability is 1 watt. The Microline 46B1 is suitable for panel mounting as shown in the outline drawing below. Minimum overall mounting clearance is 10¼ inches at maximum attenuation. The Microline 46B1 can also be supplied in a case for bench use.

MAINTENANCE & ALIGNMENT PROCEDURES

The Microline 46B1 is designed and constructed to provide long life with minimum servicing. Each instrument is fully adjusted and accurately calibrated and no maintenance, except for lubrication of the gear sets, should be necessary.

If it is ever necessary to align the coplaner coils for maximum transfer of power the following steps should be followed. Refer to the outline drawing.

1. Remove the bevel gear (1) from the 1/4 inch diameter rod.
2. Remove the three socket head screws and lockwashers (2) securing the front casting assembly to the body.
3. Remove the front casting (3) without removing, loosening, or adjusting the position of the counter readout.
4. Loosen the two screws (4) securing the slotted end plate of the coil assembly.
5. With a 30 Mc signal, from a source with a characteristic impedance of 50 ohms connected to the input, and the output connected to a sensitive indicating system, rotate the coil assembly for maximum output. (The position of the red dot on the end plate should be approximately 30° in a counter-clockwise direction from the 1/4 inch diameter gear shaft.)
6. Re-assemble in the reverse sequence.
7. After alignment of the coils, the insertion loss should be checked in the following manner. Using a sensitive attenuation measuring device, such as the Microline 61A1 Receiver, and the counter set at 000.0, an insertion loss of 23.1 ±.1 db is necessary in order to operate the attenuator in the linear region. If the insertion loss is other than previously stated, loosen the universal joint (7) to the counter and rotate the gear until the correct reading is obtained. Secure the universal joint with the counter set at the 000.0 position. If it becomes necessary to adjust the 46B1 for backlash, the adjustment is made as follows:
8. Loosen the setscrew (8) used to hold the position-threaded collar.
9. With a 30 Mc source connected to the input and an extremely sensitive indicator system such as the 61A1 connected to the output, set a reference level and observe the db reading on the counter.
10. Turn the attenuator knob and reset the counter to the previously observed db reading.
11. Adjust the threaded collar (11) on the drive tube until the indicator reference level is the same as in step 9.
12. Turn the attenuator and reset to the previously observed db reading, step 8. If the reference level deviates, repeat steps 10 and 11 until the reference level repeats.
13. Tighten and glyptal the setscrew (8) to hold this position of the threaded collar.


11
8
3
2
2-7/16
1-7/16
A
1
1/4 DIA.
INPUT
7
A
6-1/16
19/32
10-1/4 MAX.
RED DOT
4
SECTION A-A
2
1"
1"
1.500±.015
4
.290±.005
.604±.005

MANUFACTURER'S CODE

A Aerovox Corp.
New Bedford, Mass.

B Amperex Electronics Corp.
Hicksville, N. Y.

C Allen-Bradley Co.
Milwaukee 4, Wis.

D Aemco, Inc.
Mankato, Minn.

E Arrow, Hart and Hegeman
Hartford Conn.

F Advance Electric & Relay Co.
Burbank, Calif.

G Alcon Metal Products, Inc.
Chicago, Ill.

H Amphenol Electronics Corp.
Chicago 50, Ill.

I Amperite Co.
New York, N. Y.

J Astron Corp.
East Newark, N. J.

K All Star Products, Inc.
Defiance, Ohio

L Any brand tube meeting
EIA standards

M Beede Electrical Instrument Co.
Penacook, N. H.

N Belden Mfg. Co.
Chicago 44, Ill.

O Bud Radio Inc.
Cleveland, Ohio

P Barber-Colman Co.
Rockford, Ill.

Q Bussman Mfg. Co.
St. Louis, Mo.

R Birnbach Radio Co.
New York 13, N. Y.

S Sperry Microwave Electronics Co.
Clearwater, Fla.

T Clarostat Mfg. Co.
Dover, N. H.

U Chicago Telephone Supply
Elkhart, Ind.

V Centralab Div. Globe Union, Inc.
Milwaukee 1, Wis.

W Cinch-Jones Mfg. Co.
Chicago 24, Ill.

X Corning Glass Works
Bradford, Pa.

Y California Resistor Corp.
Santa Monica, Calif.

Z Cornell-Dubilier Electric Co.
So. Plainfield, N. J.

AA Dage Electric Co., Inc.
Beech Grove, Ind.

AB Dial Light Co. of America
Brooklyn 37, N. Y.

AC Dale Products, Inc.
Columbus, Neb.

AD Hugh H. Eby Co.
Philadelphia, Pa.

AE Erie Resistor Corp.
Erie 6, Pa.

AF Essex Electronics, Inc.
Berkeley Heights, N. J.

AG Electro Motive Mfg. Co.
Willimantic, Conn.

AH Electra Mfg. Co.
Kansas City, Mo.

AI General Electric Co.
Owensboro, Ky.

AJ Florida Transformer Co.
De Leon Springs, Fla.

AK Gremar Mfg. Co.
Wakefield, Mass.

AL Hammarlund Mfg. Co., Inc.
New York 1, N. Y.

AM Heyman Mfg. Co.
Kenilworth, N. J.

AN Hi-Q Div. of Aerovox Corp.
Myrtle Beach, S. C.

AO IEI
Nashville, Tenn.

AP Industrial Devices, Inc.
Edgewater, N. J.

AQ International Rectifier Corp.
El Segundo, Calif.

AR International Resistance Co. (IRC)
St. Petersburg, Fla.

AS E. F. Johnson Co.
Waseca, Minn.

AT James Millen Mfg. Co., Inc.
Malden, Mass.

AU Kulka Electric Mfg. Co., Inc.
Mount Vernon, N. Y.

AV Kelvin Electric Co.
Van Nuys, Calif.

AW Line Electric Co.
Newark, N. J.

AX Littelfuse, Inc.
Des Plaines, Ill.

AY M.E.C.
Nashville, Tenn.

AZ J. W. Miller Co.
Los Angeles, Calif.

BA Motorola, Inc.
Phoenix, Ariz.

BC North American Electronics, Inc.
Lynn, Mass.

MANUFACTURER'S CODE (Continued)

BD Oak Mfg. Co.
Chicago 10, Ill.

BE Ortho Industries
Paterson, N. J.

BF Potter and Brumfield, Inc.
Princeton, Ind.

BG Plastic Capacitors, Inc.
Chicago, Ill.

BH Peterson Radio Co.
Council Bluffs, Ia.

BI Philco Corp.
Lansdale, Pa.

BJ Raytheon Mfg. Co.
Newton, Mass.

BK Radio Materials Co. (R.M.C.)
Chicago, Ill.

BL R.C.A. Tube Division
Harrison, N. J.

BM Radio Receptor Co., Inc.
Brooklyn, N. Y.

BN Superior Electric Co.
Bristol, Conn.

BO Sylvania Electric
Emporium, Pa.

BP Switchcraft, Inc.
Chicago 22, Ill.

BQ Herman H. Smith, Inc.
Brooklyn, N. Y.

BR Synchro Corp.
Hicksville, Ohio

BS Sloan Co.
Burbank, Calif.

BT Triad Transformer Co.
Huntington, Ind.

BU Tepro of Florida, Inc.
Dunedin, Fla.

BV Texas Instruments, Inc. (T.I.)
Dallas, Texas

BW Transformer Technician, Inc.
Chicago, Ill.

BX Tung-Sol Electric, Inc.
Newark 4, N. J.

BY Unimax Switch Division
Wallingford, Conn.

BZ Veeder Root, Inc.
Hartford, Conn.

CA Winchester Electronics, Inc.
Santa Monica, Calif.

CB Walsco
Rockford, Ill.

CC Workman TV
Sarasota, Fla.

CD United International Dynamics Corp.
Waltham, Mass.

CE The Muter Co.
Chicago 5, Ill.

CF Columbus Electronics
Yonkers, N. Y.

The use of vacuum tubes in this product imprinted with the *Viewlux* trademark does not imply that these are selected tubes. In the event that selected components are required, they will be described in detail in the manual.

TABLE OF REPLACEABLE PARTS

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity Per Unit
B1	Bulb, Neon, NE2A	BX	A-01852-3	2
B501	Same as B1			
C1	Capacitor: 100/100 uf, -10% +100%, 50 wvdc	A	C-02235-207	1
C2	Capacitor: 40/40 uf, -10% +100%, 250 wvdc	A	C-02235-208	1
C3	Capacitor: 0.22 uf, 20%, 200 wvdc	A	A-01202-207	3
C4	Capacitor: 20/20 uf, -10% +100%, 250 wvdc	A	C-02235-201	1
C5	Capacitor: 0.1 uf, 20%, 200 wvdc	A	A-01202-205	11
C6	Capacitor: 20 uf, -10% +100%, 250 wvdc	A	A-01230-7	4
C101	Capacitor: 0.005 uf, +80% -20%, 500 wvdc	BK	A-01210-005	43
C102	Capacitor: 39 pf, 5%, 300 wvdc	A	610793-13	1
C103	Capacitor: 470 pf, 5%, 300 wvdc	A	610793-39	1
C104	Same as C101			
C105	Capacitor: 100 pf, 10% 600 wvdc	V	A-01205-101	1
C106	Same as C101			
C107	Same as C101			
C108	Same as C101			
C109	Capacitor: 20 pf, 5%, 300 wvdc	A	610793-06	1
C110	Not Used			
C111	Same as C101			
C112	Capacitor: 0.001 uf, 20%, 500 wvdc	V	A-01260-102	6
C113	Same as C112			
C114	Same as C112			
C115	Same as C101			
C116	Same as C101			
C117	Same as C101			
C118	Capacitor: 0.001 uf, GMV, 500 wvdc	BK	A-01210-001	6
C201	Capacitor: 30/30 uf, -10% +100%, 350 wvdc	A	A-01236-5	1
C202	Capacitor: 20/20 uf, -10% +100%, 250 wvdc	A	A-01236-1	2
C203	Same as C5			
C204	Capacitor: 0.01 uf, +80% -20%, 500 wvdc	BK	A-01210-010	12
C205	Same as C5			
C206	Same as C5			
C207	Capacitor: 2 uf, +20% -10%, 1000 wvdc	A	A-01217-102	1
C208	Same as C6			
C209	Same as C118			
C301	Capacitor: 820 pf, 5%, 300 wvdc	A	015-23	1
C302	Same as C3			
C303	Capacitor: 25 uf, -10% +250%, 25 wvdc	A	A-01230-2	7
C304	Same as C204			
C305	Capacitor: 0.47 uf, 20%, 200 wvdc	A	A-01202-209	2
C306	Same as C204			
C307	Same as C101			
C308	Capacitor: 10 pf, 10%, 600 wvdc	V	A-01205-100	1
C309	Same as C204			
C310	Same as C5			
C311	Same as C303			
C312	Same as C204			

TABLE OF REPLACEABLE PARTS (Continued)

Reference* Designation	Description	Mfr. Code	Sperry Part No.	Quantity Per Unit
C313	Same as C204			
C314	Same as C3			
C315	Same as C204			
C316	Same as C6			
C317	Capacitor: 560 pf, 5%, 300 wvdc	A	011-49	1
C318	Capacitor: Var, 15-130 pf, 250 wvdc	AG	A-01240-1	1
C319	Same as C305			
C320	Same as C204			
C321	Capacitor: 0.022 uf, 20%, 200 wvdc	A	A-01202-202	1
C322	Same as C101			
C323	Same as C204			
C401	Capacitor: 51 pf, 5%, 300 wvdc	A	610793-16	1
C402	Same as C101			
C403	Capacitor: 330 pf, 10%, 600 wvdc	V	A-01205-331	5
C405	Same as C118			
C406	Same as C101			
C407	Same as C101			
C408	Same as C101			
C409	Same as C403			
C410	Same as C118			
C411	Same as C101			
C412	Same as C101			
C413	Same as C403			
C414	Same as C101			
C415	Same as C101			
C416	Same as C101			
C417	Same as C403			
C418	Same as C101			
C419	Capacitor: 47 pf, 5%, 300 wvdc	A	610793-15	2
C420	Same as C419			
C421	Same as C101			
C422	Same as C101			
C423	Capacitor: 22 pf, 5%, 300 wvdc	A	610793-07	2
C424	Same as C423			
C425	Same as C118			
C426	Same as C118			
C427	Same as C101			
C428	Same as C101			
C429	Same as C101			
C430	Same as C101			
C431	Same as C101			
C432	Same as C101			
C433	Same as C101			
C434	Same as C101			
C435	Same as C101			
C436	Same as C101			
C437	Same as C101			

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity Per Unit
C438	Same as C101			
C439	Same as C101			
C440	Same as C101			
C501	Same as C5			
C502	Same as C5			
C503	Same as C204			
C504	Same as C5			
C505	Same as C101			
C506	Same as C303			
C507	Same as C204			
C508	Same as C5			
C509	Same as C5			
C510	Same as C6			
C511	Same as C202			
C512	Same as C101			
C513	Same as C5			
C514	Same as C303			
C515	Same as C303			
C516	Same as C303			
C517	Same as C101			
C518	Same as C303			
C601	Same as C204			
C602	Same as C101			
C701	Same as C101			
C702	Capacitor: Var, 7-45 pf, 500 wvdc	AE	0282-5	1
C703	Same as C112			
C704	Same as C112			
C705	Same as C101			
C706	Capacitor: 15 pf, 10%, 600 wvdc	V	A-01205-150	1
C707	Same as C112			
CR1	Rectifier: 2E4	AQ	A-01952	21
CR2	Same as CR1			
CR3	Same as CR1			
CR4	Same as CR1			
CR5	Same as CR1			
CR6	Same as CR1			
CR7	Same as CR1			
CR8	Same as CR1			
CR9	Rectifier: 1N3208	BA	A-1953-051	2
CR10	Same as CR9			
CR11	Same as CR1			
CR12	Same as CR1			
CR13	Same as CR1			
CR14	Same as CR1			
CR15	Same as CR1			
CR16	Same as CR1			
CR101	Diode: 1N270	BM	A-1950-2	3

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity Per Unit
CR201	Same as CR1			
CR202	Same as CR1			
CR203	Same as CR1			
CR204	Same as CR1			
CR205	Same as CR1			
CR206	Same as CR1			
CR301	Same as CR1			
CR302	Diode: 1N67A	BM	A-01950-1	7
CR303	Same as CR302			
CR401	Same as CR302			
CR402	Same as CR302			
CR501	Same as CR302			
CR502	Same as CR302			
CR503	Same as CR302			
CR701	Same as CR101			
CR702	Same as CR101			
F601	Fuse: 2 amp, 125 v	Q	A-01790-2	1
I601	Lamp, Neon	AP	A-02850-1	1
J401	Connector: BNC, UG-1094	AA	A-01752	1
J402	Connector: Phono Jack	BP	A-01729-1	3
J403	Same as J402			
J404	Connector: Test Jack	AS	A-1720-1	1
J501	Same as J402			
J601	Connector	CA	A-1740-1	1
J602	Connector: BNC, UG-912/U	AA	A-1754-4	2
J603	Connector: BNC, UG-290A/U	AA	603306	1
J604	Connector: BNC, UG-625	AK	A-01751	3
J605	Connector: Phone Jack	BP	A-01731-2	1
J606	Same as J602			
J607	Same as J604			
J608	Same as J604			
J609	Connector: Bulkhead Jack, UG-909/U	AA	A-01754-2	1
L1	Choke: 5 H	AJ	C-02461	1
L101	Coil: Var	AZ	C-02486-1	1
L102	Coil: Var	AZ	C-02486-4	1
L103	Coil: 15 uh	AZ	C-02475-156	14
L104	Same as L103			
L105	Same as L103			
L106	Same as L103			
L107	Coil: 1.5 uh	AF	C-02476-157	10
L108	Same as L107			
L109	Same as L103			
L110	Same as L103			
L401	Coil: 3 uh	AZ	B-02477-337	1
L402	Coil, Var	AZ	C-02486-1	1
L403	Same as L103			
L404	Coil: Var	AZ	C-02486-5	5

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity Per Unit
L405	Same as L103			
L406	Same as L404			
L407	Same as L107			
L408	Same as L404			
L409	Same as L107			
L410	Same as L404			
L411	Same as L404			
L412	Coil: Var	AZ	C-02486-6	1
L413	Same as L107			
L414	Same as L107			
L415	Same as L107			
L416	Same as L107			
L417	Same as L107			
L418	Same as L107			
L701	Same as L103			
L702	Same as L103			
L703	Same as L103			
L704	Same as L103			
L705	Same as L103			
L706	Same as L103			
M601	Meter: (Null)	M	B-02508	1
M602	Meter: (Output)	M	C-02507	1
M603	Meter: (Freq. Dev.)	M	C-02510	1
Mot. 1	Fan	P	A-01900-2	1
P101	Connector: BNC Plug, UG-88/U	AA	A-01750-1	1
P401	Connector	W	A-01728-206	1
P402	Connector: Phono Plug	BP	A-01729-2	3
P403	Same as P402			
P501	Same as P402			
P601	Connector: Plug	N	A-01700-2	1
P602	Connector: Plug	CA	A-1740-2	1
P603	Connector: Plug	W	A-01728-106	1
P701	Connector: BNC UG-913	AA	A-1750-7	1
P702	Connector: BNC Angle Plug	AA	A-1750-8	1
Q1	Transistor: 2N176	BA	A-01961	2
Q2	Same as Q1			
Q3	Transistor: 2N1381	BV	A-01962	2
Q4	Transistor: 2N1363	BA	A-01963-1	1
Q301	Transistor: 2N388A	BV	A-01964-8	1
Q501	Transistor: 2N398A	BV	A-01964-7	
R1	Resistor, Fixed, Composition: 2 w, 68 Ω, ±5%	C	0526-21	2
R2	Resistor, Fixed, Composition: 1 w, 1 k, ±5%	C	0525-49	2
R3	Same as R1			
R4	Resistor, Fixed, Composition: 1 w, 10 Ω, ±5%	C	0525-1	1
R5	Resistor, Var, Wire Wound: 1½ w, 25 Ω, ±20%	U	A-01186-250	1
R6	Resistor, Fixed, Composition: 1 w, 47 Ω, ±5%	C	0525-17	1
R7	Resistor, Fixed, Composition: ½ w, 200 Ω, ±5%	C	0524-32	3

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity Per Unit
R8	Resistor, Fixed, Composition: ½ w, 300 Ω, ±5%	C	0524-36	1
R9	Same as R7			
R10	Resistor, Fixed, Composition: ½ w, 100 Ω, ±5%	C	0524-25	6
R11	Not Used			
R12	Resistor, Wirewound, Power: 5 w, 2000 Ω, ±5%	T	A-01110-202	1
R13	Resistor, Wirewound, Power: 5 w, 1000 Ω, ±5%	T	A-0111-102	1
R14	Resistor, Thermistor, Globar: 150 ma, 50 Ω	CC	A-01140-1	1
R15	Resistor, Var, Composition: ¼ w, 100 k, ±30%	U	A-01151-104	3
R16	Same as R15			
R101	Resistor, Fixed, Composition: ½ w, 47 k, ±5%	C	0524-89	3
R102	Resistor, Fixed, Composition: ½ w, 220 Ω, ±5%	C	0524-33	1
R103	Resistor, Fixed, Composition: ½ w, 2200 Ω, ±5%	C	0524-57	3
R104	Resistor, Fixed, Composition: ½ w	C	0524-97	13
R105	Resistor, (Pot) Var, Carbon: 2 w, 5 k, ±20%	U	A-01170-502	1
R106	Resistor, Fixed, Composition: ½ w, 180 Ω, ±5%	C	0524-31	1
R107	Resistor, Fixed, Composition: ½ w, ~~10 k~~ 5100-2, ±5%	C	~~0524-73~~ 0524-66	8
R108	Same as R10			
R109	Resistor, Fixed, Composition: ½ w, 22 Ω, ±5%	C	0524-9	2
R110	Resistor, Fixed, Composition: 2 w, 180 Ω, ±5%	C	0526-31	2
R111	Same as R110			
R201	Resistor, Fixed, Composition: ½ w, 1 Meg, ±5%	C	0524-121	17
R202	Same as R201			
R203	Resistor, Fixed, Composition: 2 w, 7500 Ω, ±5%	C	0526-70	1
R204	Resistor, Wirewound, Power: 5 w, 2 k, ±5%	T	A-01110-202	1
R205	Resistor, Wirewound, Power: 5 w, 3500 Ω, ±5%	T	A-01110-352	1
R206	Resistor, Dep. Carbon: 1 w, 499 Ω, ±1%	AC	A-01116-268	1
R207	Same as R104			
R208	Resistor, Dep. Carbon: 1 w, 24.9 k, ±1%	AC	A-01116-439	1
R209	Resistor, Var, Wirewound: 2 w, 10 k, ±10%	U	A-01189-103	1
R210	Resistor, Fixed, Composition: 1 w, 2200 Ω, ±5%	C	0525-57	
R211	Same as R104			
R212	Same as R104			
R213	Same as R201			
R214	Resistor, Fixed, Composition: 1 w, 470 Ω, ±5%	C	0525-41	1
R215	Same as R104			
R216	Same as R201			
R217	Same as R101			
R218	Resistor, Fixed, Composition: ½ w, 1 k, ±5%	C	0524-49	4
R219	Resistor, Fixed, Composition: ½ w, 3900 Ω, ±5%	C	0524-63	1
R220	Resistor, Fixed, Composition: ½ w, 15 k, ±5%	C	0524-77	2
R221	Resistor, Fixed, Composition: 1 w, 24 k, ±5%	C	0525-82	1
R301	Resistor, Dep. Carbon: ½ w, 68.1 k, ±1%	AC	A-01115-481	2
R302	Same as R301			
R303	Same as R201			
R304	Resistor, Fixed, Composition: ½ w, 150 k, ±5%	C	0524-101	3
R305	Resistor, Fixed, Composition: ½ w, 2 k, ±5%	C	0524-56	1
R306	Resistor, Var, Wirewound: 1½ w, 1500 Ω, ±20%	U	A-01186-152	1

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity Per Unit
R307	Same as R201			
R308	Resistor, Fixed, Composition: ½ w, 330 Ω, ±5%	C	0524-37	2
R309	Resistor, Fixed, Composition: ½ w, 5600 Ω, ±5%	C	0524-67	1
R310	Resistor (Bulb, Type 3S6): 3 w, 117 v	BX	A-01852-4	1
R311	Resistor (Pot) Var, Composition: ¼ w, 250 k, ±30%	U	A-01151-254	1
R312	Same as R103			
R313	Same as R104			
R314	Resistor, Fixed, Composition: ½ w, 470 k, ±5%	C	0524-113	3
R315	Resistor, Fixed, Composition: ½ w, 1.1 Meg, ±5%	C	0524-122	1
R316	Same as R101			
R317	Same as R201			
R318	Same as R314			
R319	Resistor, Fixed, Composition: ½ w, 27 k, ±5%	C	0524-83	2
R320	Resistor, Fixed, Composition: ½ w, 22 k, ±5%	C	0524-81	2
R321	Same as R201			
R322	Resistor, Fixed, Composition: ½ w, 1500 Ω, ±5%	C	0524-53	2
R323	Resistor, Fixed, Composition: ½ w, 470 Ω, ±5%	C	0524-41	3
R324	Resistor, Fixed, Composition: ½ w, 270 Ω, ±5%	C	0524-107	2
R325	Resistor, Fixed, Composition: ½ w, 20 k, ±5%	C	0524-80	2
R326	Resistor, Fixed, Composition: ½ w, 680 Ω, ±5%	C	0524-45	1
R327	Same as R319			
R328	Same as R304			
R329	Resistor, (Pot) Var, Carbon: 2 w, 100 k ±20%	U	A-01171-105	1
R330	Same as R304			
R331	Same as R320			
R332	Resistor, Fixed, Composition: ½ w, 820 Ω, ±5%	C	0524-47	1
R333	Same as R201			
R334	Resistor, Fixed, Composition: 2 w, 510 Ω, ±5%	C	0526-42	1
R335	Resistor, Fixed, Composition: ½ w, 2.2 Meg, ±5%	C	0524-129	1
R336	Resistor, Fixed, Composition: ½ w, 1200 Ω, ±5%	C	0524-51	1
R337	Same as R104			
R338	Same as R103			
R401	Same as R10			
R402	Same as R10			
R403	Resistor, Fixed, Composition: ½ w, ~~4700 Ω,~~ ±5%	C	~~0524-65~~	3
R404	Resistor, Fixed, Composition: 2 w, 1200 Ω, ±5%	C	0526-51	1
R405	Resistor, Fixed, Composition: ½ w, 150 Ω, ±5%	C	0524-29	3
R406	Resistor, Fixed, Composition: ½ w, 1800 Ω, ±5%	C	0524-55	2
R407	Same as R10			
R408	Same as R405			
R409	Same as R406			
R410	Same as R10			
R411	Same as R403			
R412	Same as R403			
R413	Same as R10			
R414	Same as R107			

Replace to 5600Ω
0524-67

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity Per Unit
R415	Same as R107			
R416	Resistor, Fixed, Composition: ½ w, 160 Ω, ±5%	C	0524-30	1
R417	Resistor, Fixed, Composition: 1 w, 100 Ω, ±5%	C	0525-25	1
R418	Same as R218			
R419	Same as R104			
R420	Resistor, Fixed, Composition: 1 w, 18 k, ±5%	C	0525-79	1
R421	Same as R218			
R422	Resistor, Fixed, Composition: 1 w, 10 k, ±5%	C	0525-73	2
R423	Resistor, Fixed, Composition: ½ w, 200 k, ±5%	C	0524-104	3
R424	Same as R423			
R425	Same as R218			
R426	Same as R107			
R427	Same as R107			
R428	Resistor, Fixed, Composition: ½ w, 24 Ω, ±5%	C	0524-10	2
R429	Same as R428			
R430	Same as R201			
R501	Not Used			
R502	Resistor, Fixed, Composition: ½ w, 75 Ω, ±5%	C	0524-22	1
R503	Resistor, Fixed, Composition: ½ w, 220 k, ±5%	C	0524-105	1
R504	Same as R201			
R505	Same as R314			
R506	Same as R104			
R507	Same as R7			
R508	Resistor, Fixed, Composition: ½ w, 30 k, ±5%	C	0524-84	1
R509	Same as R107			
R510	Resistor, Fixed, Composition: ½ w, 240 k, ±5%	C	0524-106	3
R511	Same as R201			
R512	Resistor, Fixed, Composition: 1 w, 3300 Ω, ±5%	C	0525-61	1
R513	Same as R308			
R514	Same as R2			
R515	Resistor, Fixed, Composition: ½ w, 510 k, ±5%	C	0524-114	1
R516	Resistor, Fixed, Composition: ½ w, 3300 Ω, ±5%	C	0524-61	2
R517	Same as R104			
R518	Same as R201			
R519	Same as R422			
R520	Same as R516			
R521	Same as R104			
R522	Same as R422			
R523	Same as R220			
R524	Resistor, Dep. Carbon: ½ w, 82.5 k, ±1%	AC	A-01115-489	2
R525	Same as R524			
R526	Resistor, (Pot), Var, Composition: 1/3 w, 25 k, ±30%	U	A-01151-253	1
R527	Resistor, (Pot) Var, Composition: ½ w, 10 k, ±30%	U	A-01151-103	1
R528	Same as R107			
R529	Same as R107			

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity Per Unit
R530	Same as R405			
R531	Same as R405			
R532	Same as R15			
R533	Same as R201			
R534	Same as R324			
R535	Same as R510			
R536	Same as R510			
R537	Same as R201			
R538	Not Used			
R539	Resistor, Dep. Carbon: ½ w, 11 k, ±1%	AC	A-01115-405	1
R540	Resistor, Dep. Carbon: ½ w, 182 k, ±1%	AC	A-01115-526	1
R541	Same as R104			
R542	Resistor, Fixed, Composition: ½ w, 100 k, ±5%	C	0524-128	1
R543	Same as R423			
R544	Resistor, Fixed, Composition: ½ w, 62 k, ±5%	C	0524-92	1
R545	Same as R201			
R546	Same as R201			
R547	Resistor, Fixed, Composition: ½ w, 330 k, ±5%	C	0524-109	1
R601	Resistor, Fixed, Composition: ½ w, 18 k, ±5%	C	0524-79	1
R602	Resistor, (Pot) Var, Composition: 1/3 w, 50 k, ±30%	U	A-01179-503	1
R603	Resistor, (Pot) Var, Wirewound: 2 w, 5 k, ±10%	U	A-01185-502	1
R604	Resistor, (Pot) Var, Composition: 1/3 w, 25 k, ±30%	U	A-01152-253	1
R605	Resistor, (Pot) Var, Composition: ¼ w, 1 Meg, ±30%	U	A-01152-105	1
R606	Not Used			
R607	Resistor, Fixed, Composition: ½ w, 360 k, ±5%	C	0524-110	1
R608	Resistor, Fixed, Composition: 2 w, 3600 Ω, ±5%	C	0526-62	1
R609	Resistor, Fixed, Composition: 2 w, 3300 Ω, ±5%	C	0526-61	1
R610	Resistor, (Pot) Var, Composition: ½ w, 10 k, ±30%	U	A-01152-103	1
R611	Resistor, Dep. Carbon: ½ w, 3.4 Meg, ±1%	AC	A-01115-652	1
R612	Resistor, Dep. Carbon: ½ w, 1.07 Meg, ±1%	AC	A-01115-604	1
R613	Resistor, Dep. Carbon: ½ w, 249 k, ±1%	AC	A-01115-539	1
R614	Resistor, Dep. Carbon: ½ w, 90.9 k, ±1%	AC	A-01115-493	1
R615	Resistor, Dep. Carbon: ½ w, 158 k, ±1%	AC	A-01115-520	1
R616	Same as R322			
R617	Resistor, Fixed, Composition: 2 w, 110 Ω, ±5%	C	0526-26	1
R618	Resistor, Fixed, Composition: ½ w, 180 k, ±5%	C	0524-103	1
R619	Same as R325			
R701	Same as R323			
R702	Same as R323			
R703	Resistor, Fixed, Composition: ½ w, 390 Ω, ±5%	C	0524-39	1
R704	Resistor, Fixed, Composition: ½ w, 51 Ω, ±5%	C	0524-18	1
R705	Resistor, Fixed, Composition: ½ w, 82 Ω, ±5%	C	0524-23	1
R706	Same as R109			

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity Per Unit
S601	Switch, Toggle, SPST	E	A-01650-1	2
S602	Switch, Rotary, Non Shorting, 5 Position Each Section	BD	B-02664-2	1
S603	Switch, Rotary, 3 Position Each Section, 4 Sections, 3 Non Shorting, 1 Shorting	BD	B-02665-2	1
S604	Switch, Rotary, 3 Positions, 2 Sections, 1 Section Non Shorting, 1 Shorting	BD	B-02666-1	1
S605	Switch, Rotary, 7 Position, 3 Section, 1 Section Non Shorting, 2 Shorting	BD	B-02667-2	1
S606	Same as S601			
S607	Switch, Slide, Non Shorting, SPDT	CD	A-01659-112	1
T1	Transformer	AJ	D-02412	1
T201	Transformer	AJ	D-02413	1
T202	Transformer	AJ	C-02417	2
T203	Same as T202			
V1	Tube, Electron: Type 0A2	L	A-01001	2
V2	Same as V1			
V101	Tube, Electron: Type 6AW8	L	A-01025	1
V201	Tube, Electron: Type 6BX7	L	A-01033	1
V202	Tube, Electron: Type 12AX7	L	A-01065	2
V203	Tube, Electron: Type 0B2	L	A-01003	1
V301	Tube, Electron: Type 6U8	L	A-01057	1
V302	Tube, Electron: Type 12AT7	L	A-01063	1
V303	Tube, Electron: Type 12AU7	L	A-01064	2
V304	Tube, Electron: Type 6DJ8	B	A-01044	4
V401	Same as V304			
V402	Tube, Electron: Type 6EH7	B	A-01047	2
V403	Same as V402			
V404	Tube, Electron: Type 6EJ7	B	A-01048	1
V405	Tube, Electron: Type 6BH6	L	A-01028	1
V406	Tube, Electron: Type 6AL5			
V501	Same as V304			
V502	Same as V304			
V503	Tube, Electron: Type 6C4	L	A-01035	1
V504	Same as V202			
V505	Same as V303			
V506	Tube, Electron: Type 6AR8	L	A-01022	1
VR1	Diode, Zener: 1.5 M11Z	BA	A-01959-1	1
VR301	Diode, Zener: 1N715	BA	A-01959-2	1
Y101	Crystal: 30 mc	BH	C-02910	1
Z101	Choke: VHF Parasitic Suppressor	S	C-02478-1	1
Z501	Tuned Circuit: 5 ma, 10 v	BE	B-02480-1	1

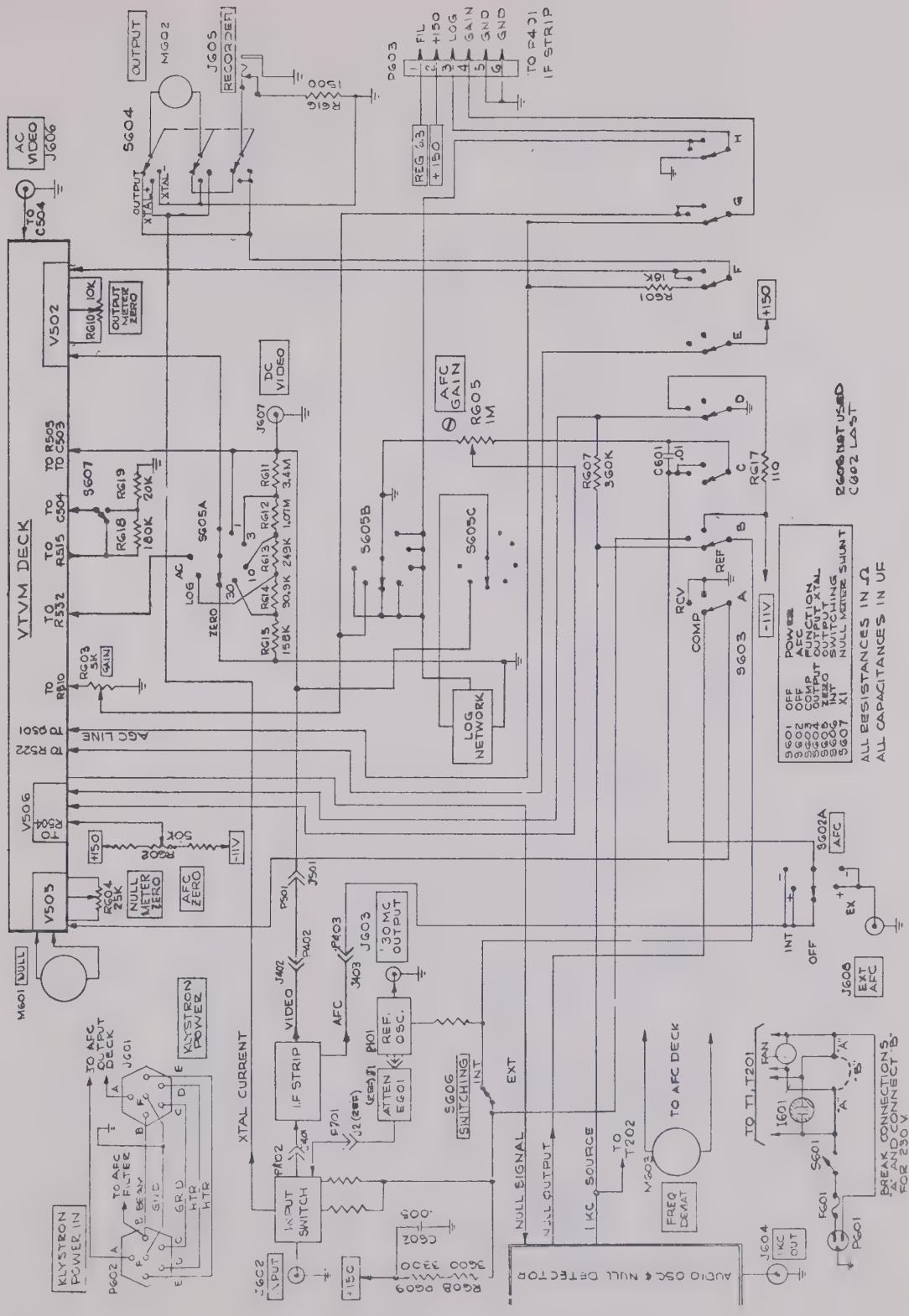


Figure 17. Interconnection Diagram

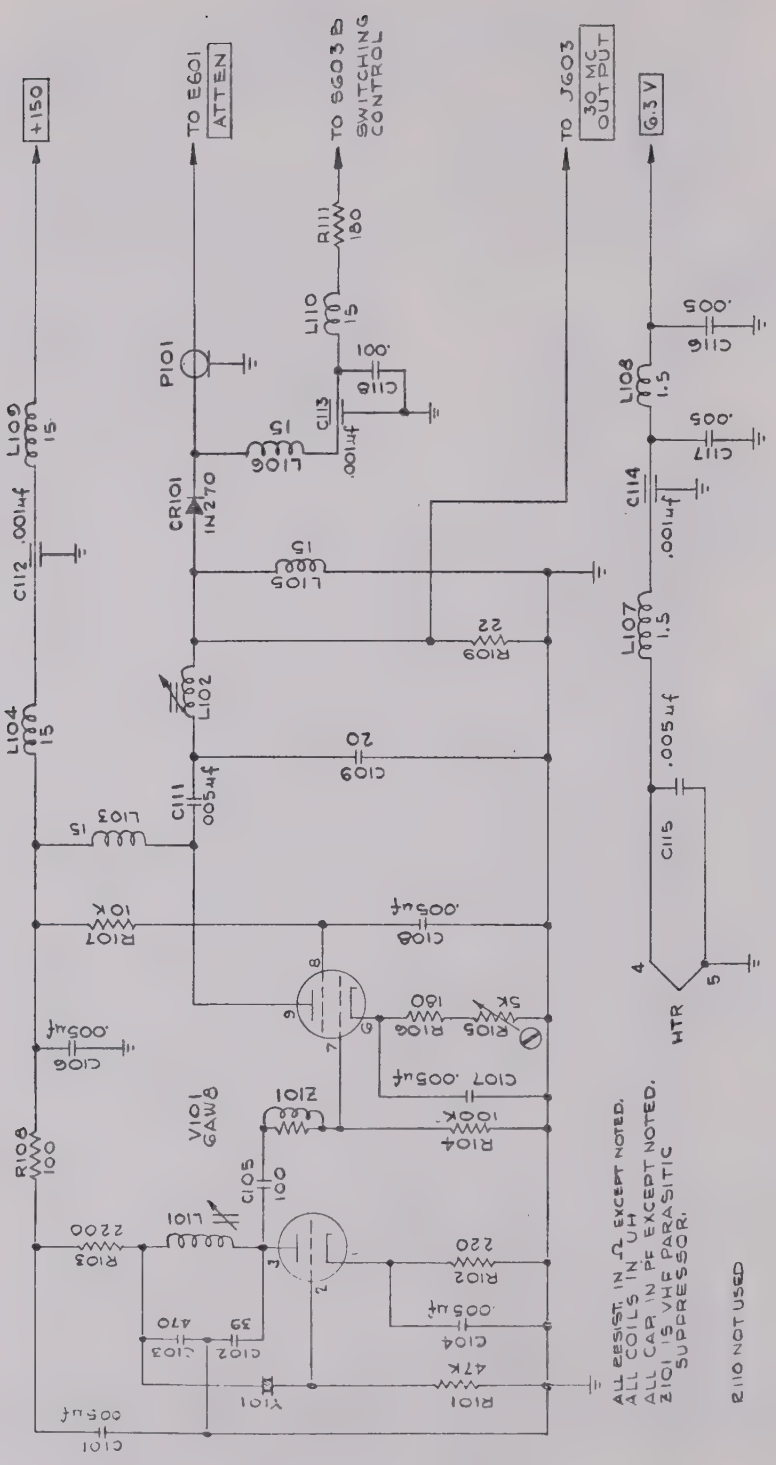


Figure 18. Reference Oscillator Schematic Diagram

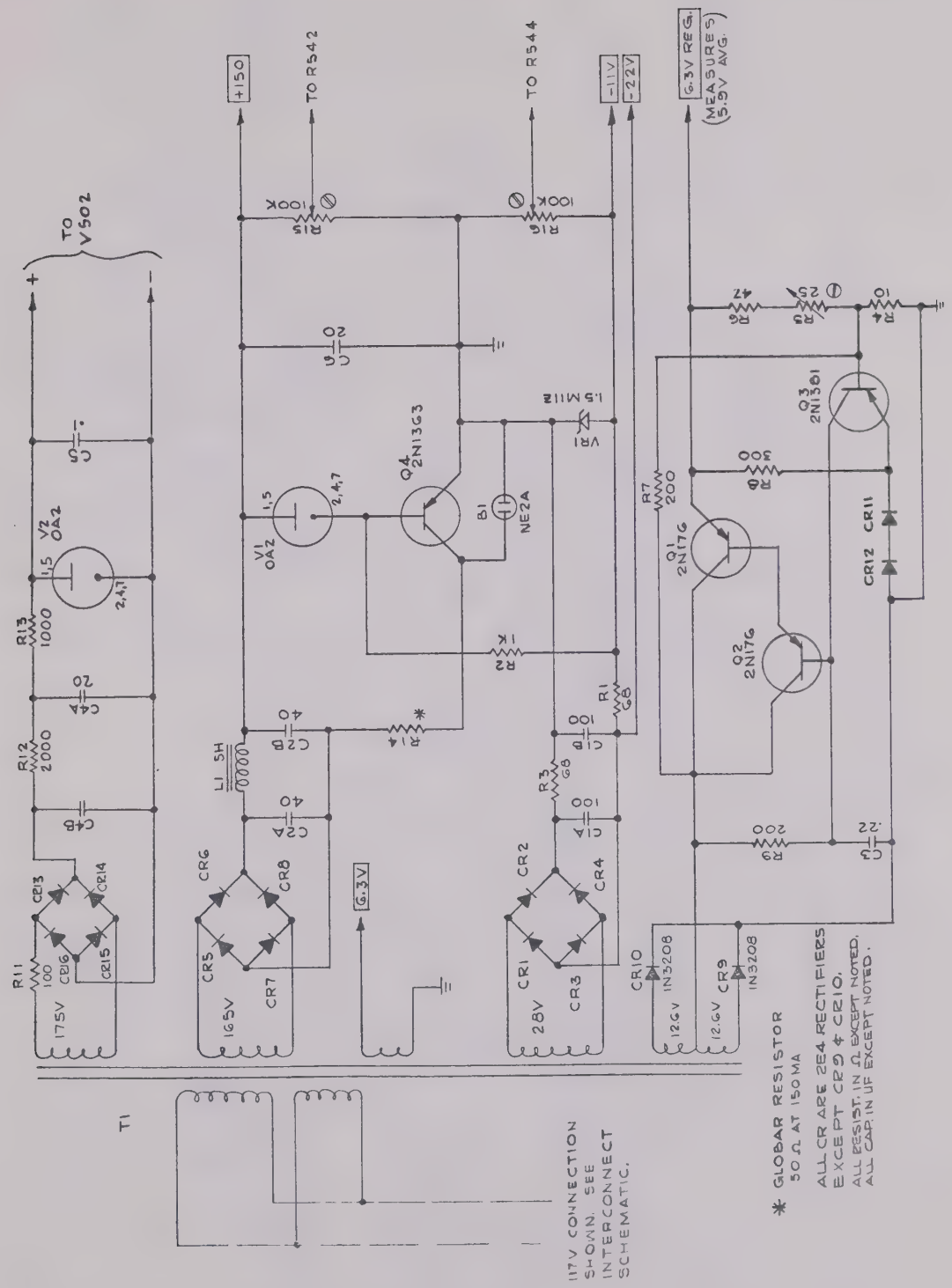


Figure 19. Power Supply Schematic Diagram

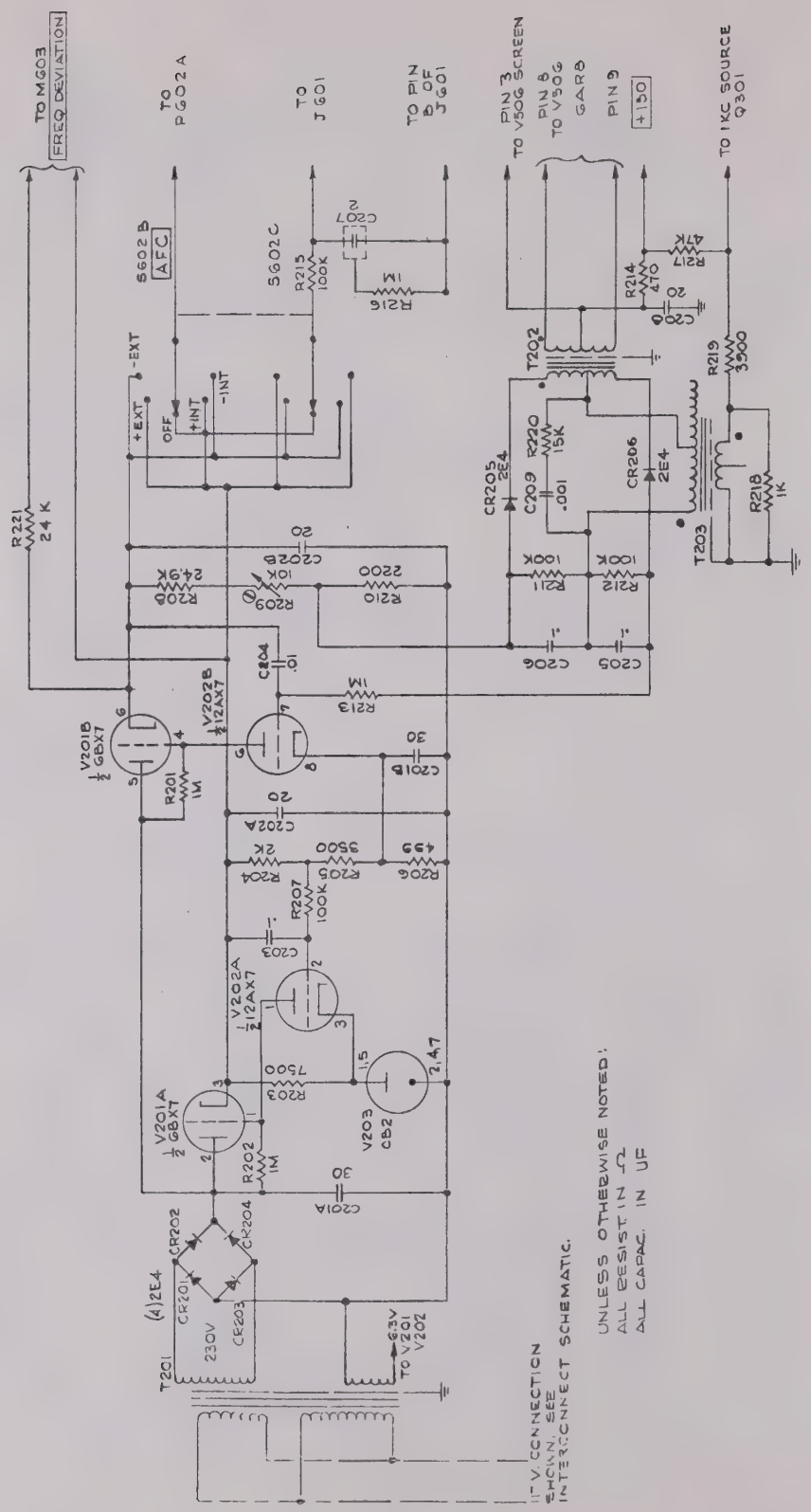


Figure 20. AFC Deck Schematic Diagram

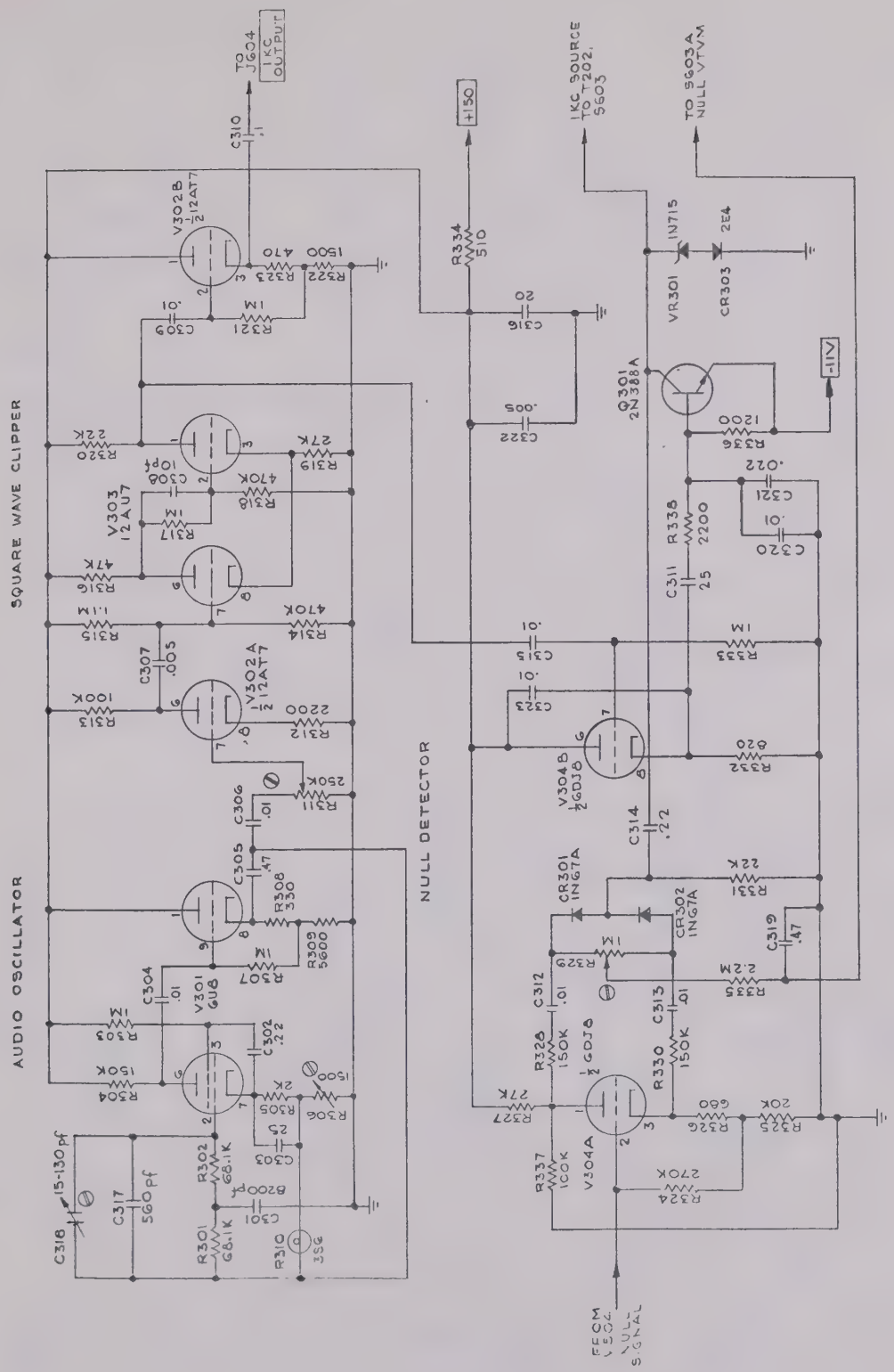


Figure 21. Audio Oscillator and Null Detector Schematic

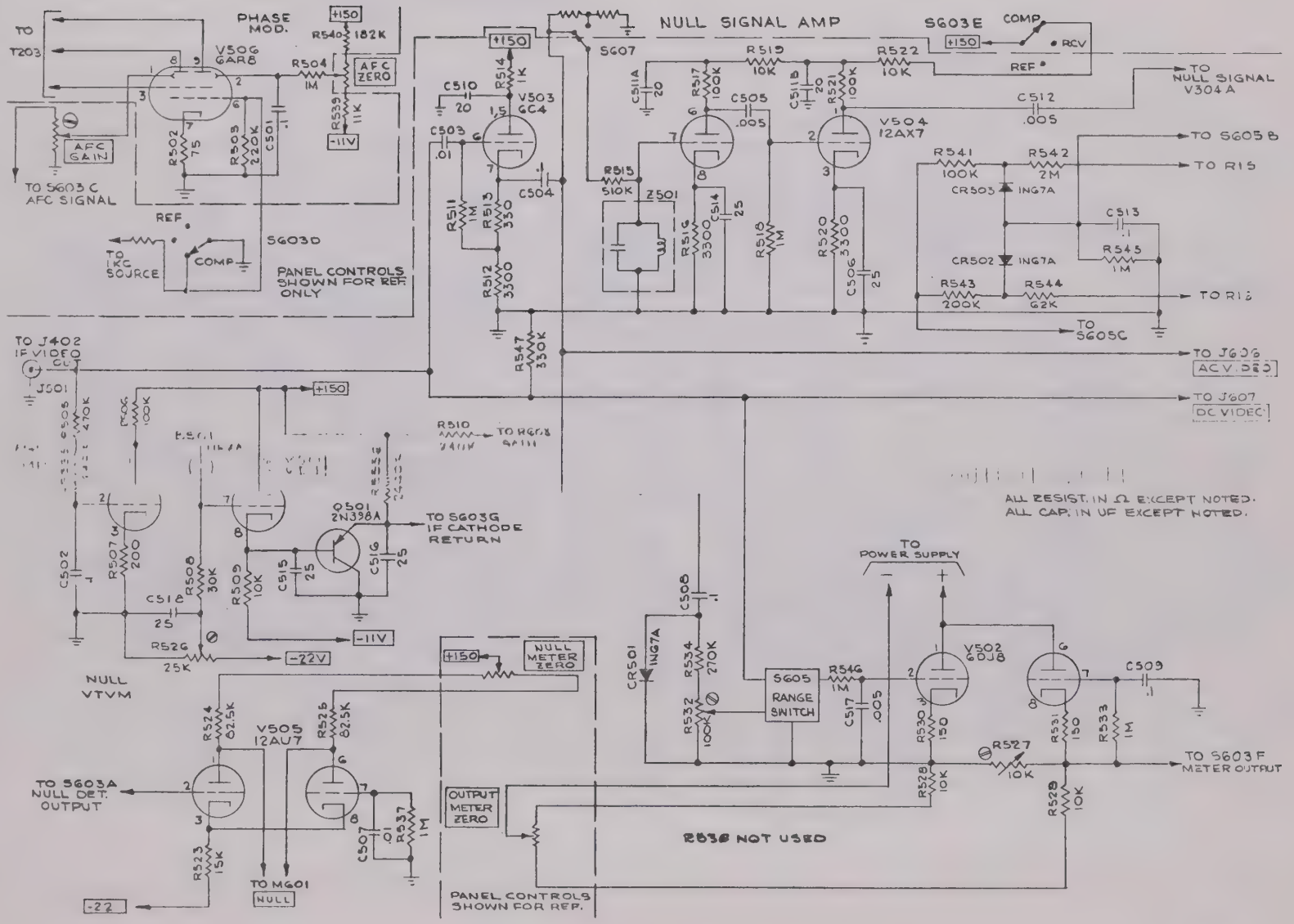


Figure 23. VTVM Deck : Schematic Diagram

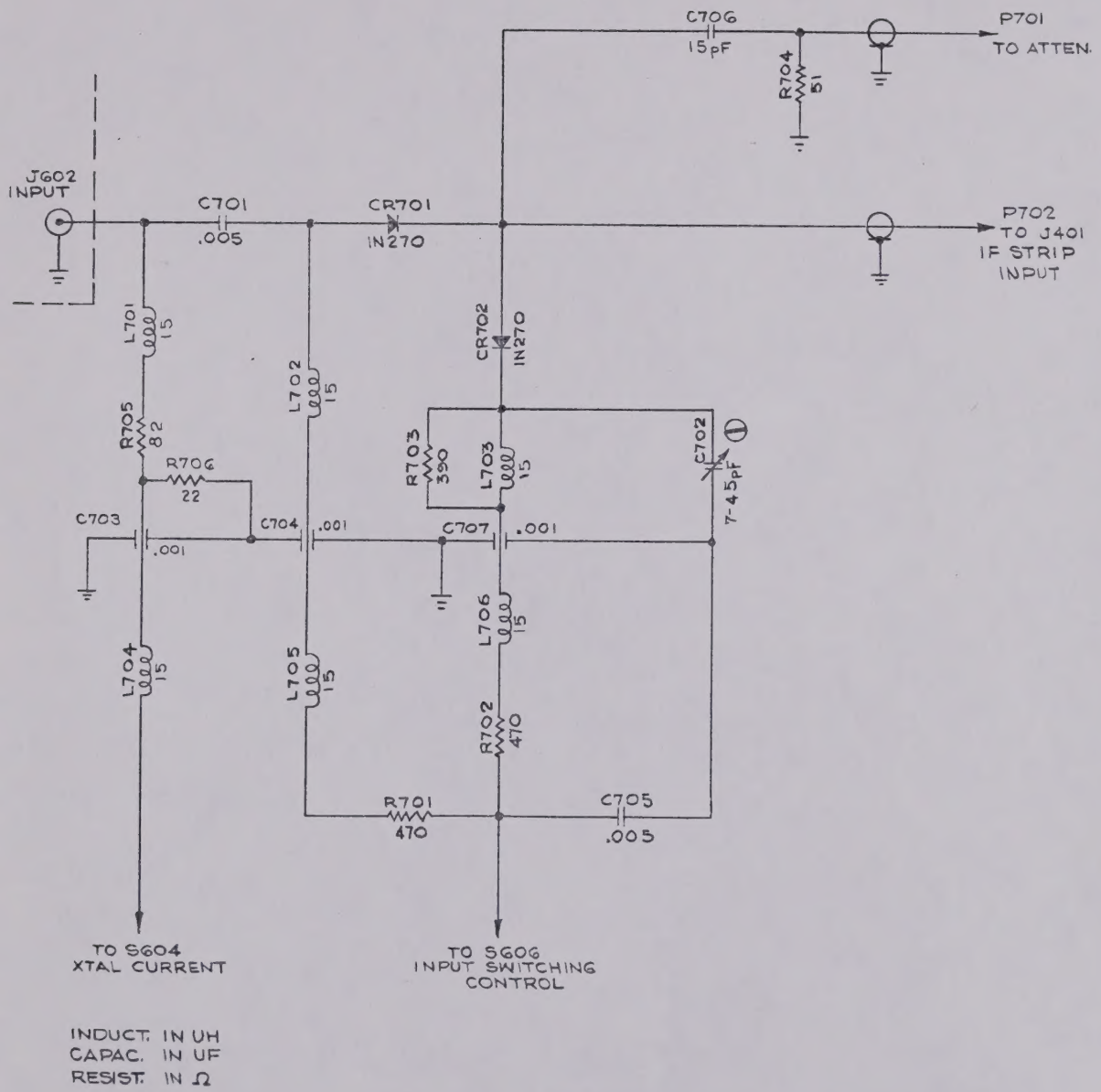


Figure 24. Input Switch Schematic Diagram

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